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РОССИЙСКОЙ ФЕДЕРАЦИИ
Государственное образовательное учреждение высшего профессионального образования
**«НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ»**
ЮРГИНСКИЙ ТЕХНОЛОГИЧЕСКИЙ ИНСТИТУТ

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АНГЛИЙСКИЙ ЯЗЫК ДЛЯ ИНЖЕНЕРОВ СВАРОЧНОГО ПРОИЗВОДСТВА

Рекомендовано Сибирским региональным учебно-методическим центром высшего профессионального образования для межвузовского использования в качестве учебного пособия для студентов, обучающихся по специальности 150202 «Оборудование и технология сварочного производства»

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Пособие содержит аутентичные тексты на английском языке, посвященные вопросам сварочного производства; упражнение направленные на развитие навыков чтения и устной речи по профессиональной тематике, а также приложения.

Предназначено для студентов вузов, обучающихся по специальности 150202 «Оборудование и технология сварочного производства».

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ВВЕДЕНИЕ

Данное учебное пособие предназначено для подготовки по английскому языку студентов высших учебных заведений, обучающихся по специальности 150202 «Оборудование и технология сварочного производства». Пособие нацелено на обучение студентов 2 – 3 курсов, уже изучивших базовый курс иностранного языка в вузе и владеющих основами грамматики и лексики общелитературного английского языка. В пособие включены аутентичные тексты на английском языке по основной сварочной тематике, снабженные упражнениями и заданиями, направленными на развитие навыков чтения, реферирования и аннотирования литературы по специальности, а также устной речи на профессиональные темы и некоторых видов письма.

Работа с материалом, представленным в пособии, поможет студентам не только овладеть английской технической терминологией из области сварки и сварочных процессов, но и познакомиться с историей и современным состоянием отрасли, заглянуть в будущее технологии.

Пособие рассчитано на 60–70 часов аудиторной и самостоятельной работы студентов.

PART 1. JOB DESCRIPTION AND WELDING EDUCATION

Lead-in

1 From the list below choose the places where welders are not likely to work.

- machine-building factory workshop
- bridge construction site
- hospital
- university department
- shipyard
- bank
- repair shop
- assembly site
- bakery

2 Choose the correct word or both to complete the definition of welding.

Welding is the process of ***cutting/joining*** pieces of ***metal/plastic detachably/permanently*** with ***metal/ceramic*** filler, using ***heat/pressure***.

Reading 1

3 Before you read do the self-rating. Answer the questions about you.

Are you good at preparing and planning a job from start to finish?	Yes	No
Can you look at a diagram or shop drawing and visualize how things come together?	Yes	No
Do you like figuring out what's wrong with something and then repairing it?	Yes	No
Are you able to bend, stretch, kneel, stand for long periods and lift material and supplies?	Yes	No
Would it bother you to work around dangerous gases and intense heat?	Yes	No
Do you have good hand/eye coordination to guide a welding arc along the edges of metal?	Yes	No

If you answered Yes to most of these questions, welder may be for you!

*4 Read the text **Welding & Machine Trades** and fill in the table with the information from the text.*

Welding professions and levels	**Trades where welding skill is used**	**Places/fields a welder can work at (in)**	**Personal qualities a welder should have**

Welding & Machine Trades

Welding is a skill used by many trades: **sheet metal workers**, **ironworker**s, diesel mechanics, boilermakers, carpenters, marine construction, steamfitters, **glaziers**, **repair and maintenance** personnel in applications ranging from the home hobbyist to heavy fabrication of bridges, ships and many other projects. A variety of welding processes are used to *join units of metal*. As a welder, you may work for shipyards, manufacturers, **contractors,** federal, state, county, and city governments, firms requiring *maintenance mechanics*, and **repair shops**.

Welding, while very physically demanding, can be very rewarding for those who enjoy working with their hands. Welders need *good eyesight*, *manual dexterity* and *hand-eye coordination*. They should also be able to concentrate for long periods of time on very detailed work, as well as be in good enough *physical shape* to bend and stoop, often holding awkward positions for long periods of time. Welders work in a variety of environments, both indoors and out, using heat to melt and fuse separate pieces of metal together. Training and skill levels can vary, with a few weeks of school or *on-the-job training* for the lowest level job and several years of school and experience for the more *skilled welding positions*.

Skilled welders often select and set up the *welding equipment*, *execute the **weld***, and then examine the welds in order to make sure they meet the *appropriate specifications*. They may also be trained to work in a variety of materials, such as plastic, titanium or aluminum. Those with less training perform more *routine tasks*, such as the welds on jobs that have already been laid out, and are not able to work with as many different materials.

While the need for welders as a whole should continue to grow about as fast as average, according the U.S. Bureau of Labor Statistics, the demand for *low-skilled welders* should decrease dramatically, as many companies move towards *automation*. However, this will be partially balanced out by the fact that the demand for **machine setter**s, operators and **tenders** should increase. And more *skilled welders* on *construction projects* and equipment repair should not be affected, as most of these jobs cannot be easily automated. Because of the increased need for highly skilled welders, those with *formal training* will have a much better chance of getting the position they desire. For those considering to prepare themselves to a *meaningful welding-career*, there are many *options available*.

There are also different professional specialties and levels, that should be understood to make an informed choice. Some of these are: welder, welding machine operator, welding technician, welding schedule developer, welding procedure writer, testing laboratory technician, welding **non destructive testing** inspector, welding supervisor, welding instructor, welding engineer.

Vocabulary

weld	сварной шов, сварка, сваривать(ся)
repair and maintenance	ремонт оборудования и уход за ним
sheet metal work	1) обработка листового металла 2) изделие из листового металла 3) работы по жести
ironworker	металлург
glazier	стекольщик
tender	1) лицо, присматривающее за кем-л., обслуживающее кого-л., что-л. 2) механик, оператор
supervisor	контролер
contractor	подрядчик, контрактор
repair shop	ремонтная мастерская
machine setting	наладка [настройка] станка
nondestructive testing	1) неразрушающие испытания; 2) неразрушающий контроль

5 Find Russian equivalents for the words and phrases in italics. Write them out into your dictionary

6 Answer the following questions on the text.

1. What are the trades where welding skills are used?

2. Where can welders work?
3. What personal characteristics should welders have?
4. How does the environment in which welders work vary?
5. What does it take to be s low-skilled/skilled welder?
6. What are welders able to do in terms of complexity of tasks and variety of materials?
7. What are the job opportunities for low-skilled/skilled welders for the nearest future as specified by the U.S. Bureau of Labor Statistics?
8. What are the advantages of having formal training for making a welding career?
9. As you see, welding includes various professional specialties and levels. What is yours?

7 Translate the following sentences from Russian into English:

1. Сфера применения сварки охватывает большое количество областей промышленности.
2. Профессия сварщика требует физической выносливости из-за частой необходимости работы в нестационарных условиях.
3. Для того чтобы стать квалифицированным сварщиком, необходима длительная теоретическая подготовка и практический опыт работы.
4. Квалифицированный сварщик должен сам уметь подбирать необходимое сварочное оборудование, материалы и технику сварки.
5. Чем выше квалификация сварщика, тем больше количество материалов, с которыми он может работать, и разнообразнее виды выполняемых работ.
6. В настоящее время имеются большие возможности для освоения профессии сварщика.

Speaking

8 Discuss with a partner what the following specialists do. Ask and answer questions according to the model.

- ***What does a welder do?***
- ***A welder uses some of various welding processes to join units of metal.***

➢ welder
➢ welding machine operator
➢ welding technician
➢ welding schedule developer

- welding procedure writer
- testing laboratory technician
- welding non destructive testing inspector

Writing

11 Write five sentences (one per each paragraph) summarizing the main ideas of the text.

Reading 2

12 Before you read say if the following statements are true or false.

1. Welding is an important process employed by modern industry.
2. All welding processes are similar.
3. All welding processes require workpieces to be heated.
4. The smallest group of welders belongs to the group of repair services.
5. Welding is the only way to join metals.

13 Read the text ***What is welding and what do welders do?*** *Check your answers in the previous exercise. Prove or correct the statements.*

What is welding and what do welders do?

Welding is the most economical and efficient way to join metals permanently. It is the only way of joining two or more pieces of metal to make them act as a single piece. Welding is vital to our economy. It is often said that over 50 % of the gross national product of the U.S.A. is related to welding in one way or another. Welding ranks high among industrial processes and involves more sciences and variables than those involved in any other industrial process. There are many ways to make a weld and many different kinds of welds. Some processes cause sparks and others do not even require extra heat. Welding can be done anywhere… outdoors or indoors, underwater and in outer space.

Nearly everything we use in our daily life is welded or made by equipment that is welded. Welders help build metal products from coffeepots to skyscrapers. They help build space vehicles and millions of other products ranging from oil drilling rigs to automobiles. In construction, welders are virtually rebuilding the world, extending subways, building bridges, and helping to improve the environment by building pollution control devices.

The use of welding is practically unlimited. There is no lack of variety of the type of work that is done.

Welders are employed in many industry groups. Machinery manufacturers are responsible for agricultural, construction, and mining machinery. They are also involved in bulldozers, cranes, material handling equipment, food-processing machinery, papermaking and printing equipment, textiles, and office machinery.

The fabricated metals products compiles another group including manufacturers of pressure vessels, heat exchangers, tanks, sheet metal, prefabricated metal buildings and architectural and ornamental work. Transportation is divided into two major groups: manufacturers of transportation equipment except motor vehicles; and motor vehicles and equipment. The first includes shipbuilding, aircraft, spacecraft, and railroads. The second includes automobiles, trucks, buses, trailers, and associated equipment.

A small group of welders belongs to the group of repair services. This includes maintenance and repair on automobiles or refers to the welding performed on industrial and electrical machinery to repair worn parts. The mining, oil extraction, and gas extraction industries form yet another group. A large portion of the work involves drilling and extracting oil and gas or mining of ores, stone, sand and gravel.

Welders are also employed in the primary metals industries to include steel mills, iron and steel foundries, smelting and refining plants. Much of this work is maintenance and repair of facilities and equipment. Another group is the electrical and electronic equipment companies. Welding done by this group runs from work on electric generators, battery chargers, to household appliances.

Public administration employs welders to perform maintenance welding that is done on utilities, bridges, government armories and bases, etc. Yet another group involves wholesale and retail establishments. These would include auto and agricultural equipment dealerships, metal service centers, and scrap yards.

Probably the smallest group of welders, but perhaps those with the biggest impact on the public are the artist and sculptors. The St. Louis Arch is possibly one of the best known. But there are many other fountains and sculptures in cities and neighborhoods around the world.

14 Find the English equivalents for the following words and word combinations.

Валовой национальный продукт, на открытом воздухе, в помещении, космический корабль, горное оборудование, изношенные детали, домашние принадлежности.

15 Complete the following sentences with the information from the text.

1. Welding is…. 2. Welding ranks… 3. There are many kinds… 4. Welding can be made… 5. Welders can… 6. The use of welding is… 7. Welders are employed in … . Another group involves … .

Speaking

16 Divide into two groups. Name as many uses of welding as you can remember without looking into the text. Each correct sentence gets a point to your group.
Begin your sentences like this:

Welders help …
Welders are employed in …
Welders are involved in …
Welders perform …

Reading and speaking

17 Look at the list of types of welding and say which of them you can use.

Types of welding

➢ gas tungsten arc welding (GTA)	сварка неплавящимся электродом
➢ tungsten inert gas welding (TIG)	дуговая сварка вольфрамовым электродом в среде инертного газа
➢ shielded metal arc welding (SMAW)	дуговая сварка покрытым металлическим электродом
➢ electroslag welding	электрошлаковая сварка
➢ submerged arc	(дуговая) сварка под флюсом

welding (SAW)

- termite welding — термитная сварка
- alternating current welding — сварка на переменном токе
- resistance welding — (контактная) сварка сопротивлением

18 Look at the list of skills and say if you need all of them for your future job.

Job Related Skills, Interests and Values

- using and maintaining tools, material handling equipment and welding equipment;
- reading and interpreting **blueprints;**
- laying out, cutting and forming metals to specifications;
- preparing the work site;
- fitting sub-assemblies and assemblies together and preparing assemblies for welding ;
- carrying out special processes such as **welding studs and brazing**;
- ensuring quality of product/process before, during and after welding;

Vocabulary

blueprint	1) делать светокопию, копировать чертеж 2) делать разметку
brazing	пайка твердым припоем (из меди и цинка)
welding studs	приварка шпилек плавлением

19 Speak about your professional skills. Begin like this.

I can *use …*
I'm learning to *carry out…*
I want to master *using …*

20 Read about welders' training, career possibilities and wage rate in the USA and compare with those in your country.

What Preparation and Training Do You Need?

To become a Welder you should complete Grade 12 with credits in mathematics (particularly technical math) and some shop courses. Completion of an apprenticeship could take approximately 3 years including

3 periods of 8 weeks (720 hours) in-school theory. Upon successful completion of the training agreement, you will receive a Certificate of Apprenticeship.

What's Your Future as a Welder?

Most workers in this occupation work full-time, sometimes in **shift work**, usually indoors. Those with the ability to work with high-technology welding applications may have better employment opportunities. The bulk of employment opportunities can be in the non-electrical, machinery, construction and metal-fabricating industries. Some workers will become self-employed.

What is the Wage Rate for Welders?

As an apprentice you would start at a wage rate less than that of a **journeyperson.** This rate increases gradually as you gain competency. The wage range for fully qualified welders according to the Peel Halton Dufferin HRDC Wage Book is between $9.50/hr to $16.18/hr, with a median salary of $12.50/hr.

Vocabulary

journeyman (person)	наемный квалифицированный рабочий
apprentice	ученик
plate working	обработка листового металла

Speaking

21 Complete the sentences to speak about your country. To become a Welder you should complete …
Training (apprenticeship) could take …
Upon successful completion of the training, you will receive …
Most welders work (full-time/ part-time/ in shift work/ indoors/ outdoors/ self-employed)
As an apprentice you would start at a wage rate of …
The wage range for fully qualified welders is …

Reading 3

22 Imagine you are choosing a welding course. First choose what you want to learn from the list(1-7). Then read the information in the table below and choose the course to your needs.

1. You have to know how to carry out mechanical tests.
2. You are interested in welding ferrous alloys and non ferrous alloys.
3. You want to introduce computers in your welding process.
4. You are new to welding and would like to be introduced to basic welding processes.
5. You want to learn how to choose the right type of welding for your specific purposes.
6. You want to be a highly qualified and certified expert in the field of welding.
7. You want to be familiar with welding standards.

Welding Education and Consultation Training Centre

Course	Course Objectives	Course Outlines
Welding Design	The main objective of this course is to introduce welding engineers to the subject of welding design. Many factors have to be considered in this issue. These factors include: consumer requirement, technical specifications, and environmental and economical constrains	Materials properties related to welding. Welding process selection. Types of welded joints. Welding Accessibility and Inspection. Economical Analysis. Design information. Welding symbols. **Case studies**.
Welding Fundamentals	The main objective of this course is to familiarize engineers and inspectors to various aspects related to welding **technique**s, inspection and quality procedures in welding industry. The course is designed for engineers of scientists with no or little experience in the welding field.	Welding processes: Shielded metal Arc welding, Arc welding, Gas tungsten Arc welding, Submerged Arc welding & Oxyfuel welding & **electric resistance**. Cutting processes: Oxygen cutting, plasma cutting and laser cutting. Inspection of weldments: Nondestructive testing of welments. Mechanical testing of

		weldments (**tensile**, **bending**, **impact).**
Welding Inspection	The course discusses both qualification inspections and on-line inspections of welded joints. These include mechanical tests (tension, bending, impact, ...etc, and non destructive tests.	Significance of weld **discontinuities**. Welding inspection (non-destrutive testing techniques: surface inspection, magnetic particle, **volumetric**, radiography, and ultrasonic). Destructive testing techniques**: hardness**, **tension**, bending, ...etc. The control of quality during shop operations. The control of quality during **site welding**.
Non Destructive testing Certification: Magnetic Particle & Liquid Penetrant Testing (MT & PT)	Level I: Is to train inspectors to be able to pass level I examination and to be able to inspect using the chosen technique. Level II: Is to upgrade level I inspectors to be able to pass level II examination and to be able to inspect, write a report, etc in the chosen technique.	Physical principals of test. Processing. Test equipment and materials. Codes, standards, procedures and safety. Test physical principals. Equipment and radiation source. Radiographic recording. Work parameters and conditions. Defectology. Selection of techniques. Test methods according to standards. Personal safety and protection.
Welding Metallurgy	The course delineates the main changes in the microstructure and/or the morphology of the metals and alloys during welding that lead to changes in properties. Alloys discussed in the course include all types of steels, Cast Iron, Nickel, Copper alloys, ...etc	**Heat flow** in welding. Effect of pre-and-post weld **heat treatment**. Introduction to **welding metallurgy** (**hardenability** and **weldability**). Metallurgy of steels. Welding of ferrous alloys: Carbon-steels, Low alloy steels, Stainless steels, and Cast Iron. Welding of **non ferrous alloy**s: Al- Ni- and Cu-alloys. Identification and specifications of welding **filler**

		metals. Case studies.
Welding Quality Assurance	For each application, the welding process is controlled by specific code or standard. The course includes discussions of **ASME** boiler and pressure vessel code **AWS** steel structure code and other standards.	Welding co-ordination: tasks & responsibility. Quality requirements for welding. Qualification of welding procedures and welders. International codes and standards. Mechanical testing of welds. Non-destructive testing of welds. Documents for weld quality assurance. Case studies.
Welding Techniques	Selection of the welding process is very important. The course discusses the variables of each welding process and gives directions for selecting the proper process for specific application. Welding processes discussed include: SMAW, GMAW, GTAW, etc.	Overview of welding techniques and processes. Conventional techniques: arc, Oxy fuel and resistance welding. Non-conventional: plasma, electron beam, laser welding. Flame and arc cutting of metals. Computer applications in welding. Case studies.
AWS Certified welding Engineer	The highest level of certification in the field of welding	To get certified as a welding engineer you need to attend four exams: Fundamentals of science. Applied science. Fundamentals of welding. Applied welding.

Vocabulary

technique	1) техника, способ, технические приемы 2) метод, методика,
case study	учебный пример, разбор конкретного случая
oxyfuel	газоплазменный
tensile test	испытание на растяжение
bending test	испытание на изгиб
impact test	испытание на ударную вязкость
discontinuity	отсутствие непрерывности, нарушение последовательности, несплошность
volumetric	объемный

hardness	твердость, прочность, сопротивляемость (механическим воздействиям)
tension	натяжение, растяжение, растягивание, удлинение
site welding	монтажные сварочные работы
heat flow	тепловой поток
heat treatment	термическая обработка
welding metallurgy	металлургия сварки
hardenability	1) закаливаемость 2) прокаливаемость 3) способность к закаливанию
weldability	свариваемость
non-ferrous	цветной (о металле), не содержащий железа
alloy	сплав
ASME	сокр. от American Society of Mechanical Engineers Американское общество инженеров-механиков
AWS	сокр. от American Welding Society Американское сварочное общество

23 Translate the following sentences into Russian.

1. Кислородная, плазменная и газовая резка изучаются в курсе «Основы сварочного производства».
2. Методика проведения разрушающих испытаний изучается в курсе «контролер сварочного участка» («приемщик сварочных изделий»).
3. К традиционным типам сварки относятся: электродуговая, кислородно-газовая и контактная электросварка.
4. Каждый сварщик должен знать правила личной безопасности и использовать индивидуальные средства (equipment) защиты, а также разбираться в международных кодах и стандартах.
5. Во время сварки происходит изменение микроструктуры металла, что приводит к изменению его свойств.
6. При проведении монтажных, сварочных работ особенно важно контролировать качество шва.

24 Match the words (a-h) with definitions (1-8).

a) alloy, b) joint, c) inspection, d) welding, e) laser, f) property, g) plasma, h) arc

1. Joining pieces of metal (or nonmetal) at faces rendered plastic or liquid by heat or pressure (or both).

2. A junction or mode of joining parts together; b) the place where two things are joined together
3. The luminous arc or bridge across a gap between two electrodes when an electric current is sent through them.
4. A careful, narrow or critical examination or survey; b) an official examination.
5. An instrument which amplifies light waves by stimulation to produce a powerful, coherent beam of monochromatic light, an optical maser.
6. Metal blended with some other metallic or nonmetallic substance to give it special qualities, such as resistance to corrosion, greater hardness, or tensile strength.
7. Peculiar or inherent quality.
8. A hot, ionized gas containing approximately equal numbers of positive ions and electrons.

Writing

25 Make a description of the welding course you are following at the University. Use the information in Activity 22 as an example.

The name of the course	…
The course description	…
The course outline	…

Reading 4

26 You will read a text about underwater welding. Before you read make a list of questions which you would ask about this career opportunity if you were going to try it.

27 Read questions (A – F) commonly asked by those who have expressed an interest in underwater welding, but were unsure how to get start. Then read the answers (1 – 6) provided by AWS. Match each question with the suitable answer. The first is done.

A. What are the age limitations of a welder-diver?
B. I am already a certified diver, what other training do I need to qualify as a welder-diver?

C. What skills are prerequisite to entering the field of underwater welding?
D. What salary can I expect to make as a welder-diver?
E. I am a certified surface welder, what other training do I need to qualify as a welder-diver?
F. What future career opportunities are there for an experienced welder-diver?

Taking the Plunge:
A Guide to Starting an Underwater Welding Career

1	C

The skills suggested for entering the field of underwater welding can best be defined by the following typical description of a welder-diver from the AWS D3.6 Standard. "Welder-diver: A *certified welder* who is also a commercial diver, capable of performing tasks associated with commercial **subsea** work, weld setup and preparation, and who has the ability to weld in accordance with the AWS D3.6." By description, an experienced welder-diver must possess: *commercial diving skills* (i.e., be familiar with the use of specialized commercial diving equipment, have an understanding of diving physiology, diving safety, **rigging**, the underwater environment, communication, etc.); weld setup and preparation skills (i.e., the ability to perform tasks typically assigned to a **fitter** or rigger, such as materials **alignment** and materials preparation including **beveling**, **stripping** of concrete, fitting a steel **patch** or repair plate, etc.,); and the ability to certify to a required underwater weld procedure.

2	

The majority of work performed by an average welder-diver does not involve the welding operation itself, but rather executing the tasks that lead up to and follow the *actual welding activities*. Except under special circumstances, a welder-diver in most cases must posses both certified welder skills and commercial diving skills. It is suggested that if you have no prior commercial diving experience you should attend one of the recognized commercial diving schools. The candidate may be required to pass a diving physical prior to *school acceptance* and in some cases a written exam. It is suggested that a dive physical be taken regardless, to avoid going through the expense of training only to later find you have a disability that prevents your entering the profession.

3	

The welding processes, classes of weld and qualification tests associated with underwater welding are described in ANSI/AWS D3.6. We recommend the specification as a reference for weld procedure and welder qualification. It is also a good *source of other helpful information*. If you are already certified as a "commercial diver" and work for a company that offers underwater welding services, it is recommended that you *communicate to your company* your career objectives and ask what welder skills they are looking for. If you are certified as a "**scuba diver**", it is suggested that you attend a commercial diving school. Sport dive training does not include the safe use of commercial diving equipment, offshore commercial work environment/safety, and other education. Underwater welding is a skill you also have to master once you obtain the basic commercial diving skills required.

4	

There is no age restriction on commercial welder-divers. There are, however, physical requirements. It is recommended and generally required that all commercial divers pass an annual dive physical examination. The commercial diving profession is *physical demanding*. It is rare to see an active commercial welder-diver over the age of 50.

5	

We know some welder-divers earn $15,000 per year while others earn in excess of $100,000. Because the majority of welder-divers are paid on a *project-by-project basis*, salaries are subject to the same variables as work availability. In addition, other factors such as depth, dive method and diving environment affect pay rates. The company with whom you gain employment should be able to tell you the salary range you can expect to earn.

6	

There are a number of career opportunities for experienced welder-divers. Many go on to become engineers, instructors, and diving operations supervisors, *fill management positions*, qualify as AWS Certified Welding Inspectors (CWI), and serve as consultants for underwater welding operations and other related fields. Ideally, a career as a welder-diver should serve as a *stepping stone* to other opportunities for those who choose the profession.

Industry has and will continue to demand higher quality standards for underwater welds and more certification of underwater welding systems and personnel.

Vocabulary

subsea	погруженный в воду, подводный
rigging	1) оснастка; 2) сборка, регулировка, установка, монтаж (конструкций, оборудования и т.д.) 3) оборудование, оснащение, снаряжение
fitter	сборщик, слесарь-сборщик
alignment	выверка, выравнивание, регулировка
beveling	разделка кромок
stripping	сдирание, обдирание, зачистка, снятие верхнего слоя
patch	заплата
scuba diver	лёгкий водолаз, аквалангист
draft	делать чертеж, проектировать
lapse	юр. прекращение, недействительность права (на что-л.)

28 Give Russian equivalents to the words in italics.

29 Continue filling in the following table:

Operations both surface welders and welder-divers do	**Operations only welder-divers do**
weld setup and preparation, …	underwater cutting, …

30 Correct the following statements to make them correspond to the text.

1. Welder-divers must have the skills of commercial diving but need not be certified.
2. The majority of work performed by an average welder-diver includes only welding operation itself.
3. Welder-divers apply for employment at commercial diving companies before their diver training is completed.
4. Commercial welder-diver is the same as scuba diver.
5. You cannot be a welder-diver if you are over 50 years old.

6. To possess commercial diving skills means to be able to do underwater weld procedures.
7. Welder-divers earn from $15,000 to $100,000 per year depending on their work experience.
8. To pass a physical examination for welder diver you need to go through formal training.
9. Past welding experience doesn't count if you choose to be a welder-diver.

31 Answer the following questions.

1. Who can be a welder-diver?
2. What sorts of basic and supplementary skills must a welder-diver possess?
3. How can certified surface welders become welder-divers?
4. What is more important: receiving the welder-diver qualifications or maintaining them?
5. Why do commercial divers pass an annual dive physical?
6. Do welder-divers have any future career opportunities?
7. Do you think surface welding equipment can be used underwater?

32 Translate the following sentences into Russian.

1. Большое количество людей проявляет интерес к профессии подводного сварщика.
2. Сварщик-подводник –это квалифицированный сварщик, обладающий всеми навыками, необходимыми для сварки на поверхности и под водой.
3. Перед зачислением в школу сварщиков-подводников кандидаты проходят обязательное медицинское освидетельствование.
4. Полезными навыками сварщиков-подводников являются: фото- и видеосъемка, создание чертежа, установка оснастки и др.
5. Для многих профессиональных сварщиков навыки подводной сварки становятся залогом дальнейшего карьерного роста.

Speaking

33 Discuss the following questions in the group.

1. The word combination ***taking the plunge*** is a set phrase (связанное фразеологическое сочетание). Is it a good title for this text? Why?
2. Another set phrase in the text is ***a stepping stone***. What are possible stepping stones in your welding career?

Revision

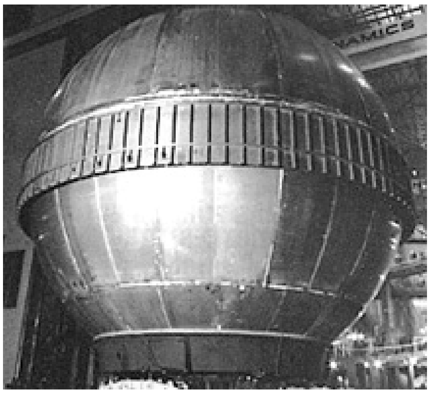
Name five

- types of welding
- places where welders can work
- welding professions
- welding courses
- job related skills

PART 2. THE HISTORY OF WELDING

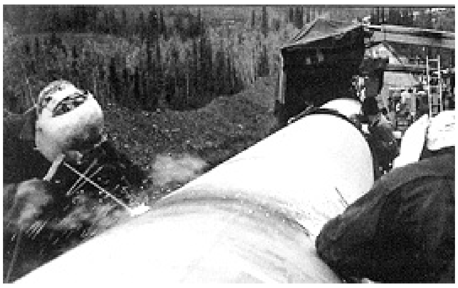
Lead-in

1 Look at pictures A, B, C of welded constructions and define what time period they refer to.



Picture A

Picture B



Picture C

Reading 1

*2 You will read the text **Welding History - A Story of Harnessing Heat.** Before you read check your knowledge of welding history by doing the short test below.*

1. The history of welding began in
    a) the Bronze Age
    b) the Middle Ages
    c) the 19th century
    d) the 20 century

2. All of the following improvements of the welding process refer to the 20th century EXEPT

a) covered electrode
b) electric arc
c) shielding gas
d) automatic welding

3. The invention attributed to a Russian inventor Benardos is

a) carbon electrode
b) acetylene
c) resistance welding
d) alternating current welding

4. The latest welding process having been introduced is

a) electrogas welding
b) laser beam welding
c) flux-cored arc welding
d) electroslag welding

3 Read the text and check your answers in the previous exercise.

Welding History - A Story of Harnessing Heat

Joining metal and welding history go back several millennia starting in the Bronze Age then Iron Age in Europe then the Middle East. Welding was used in the Iron pillar in Delhi, India, about 310 AD, weighing 5.4 metric tons (picture at left). The Middle Ages brought forge welding, blacksmiths pounded hot metal until it bonded. In 1540, Vannoccio Biringuccio released *De la pirotechnia*, which includes descriptions of the forging operation. Renaissance craftsmen gained skilled in the process, and the welding continued to grow during the following centuries.

Welding was transformed during the 19th century. In 1800, Sir Humphrey Davy invented the electric arc, and advances in welding continued with the metal electrode by a Russian, Nikolai Slavyanov, and an American, C.L. Coffin late in the 1800s.

Acetylene was discovered in 1836 by Edmund Davy, but was not practical in welding until about 1900, when a suitable blowtorch was developed. At first, oxyfuel welding was the more popular welding method due to its portability and relatively low cost. As the 20th century progressed, it fell out of favor for industrial applications. It was largely replaced with arc welding, as metal coverings (known as flux) for the electrode that stabilize the arc and shield the base material from **impurities** continued to be developed.

In 1881 a Russian inventor, Benardos demonstrated the carbon electrode welding process. An arc was formed between a moderately consumable carbon electrode and the work. A **rod** was added to provide needed extra metal.

Termite welding was invented in 1893, another process, oxyfuel welding, became well established.

Around 1900, A. P. Strohmenger brought a coated metal electrode in Britain, which had a more stable arc, and in 1919, alternating current welding was invented by C.J. Holslag, but did not become popular for another decade.

Resistance welding was developed during the end of the 19th century, with the first patents going to Elihu Thompson in 1885, and he produced advances over the next 15 years.

In 1904 Oscar Kjellberg in Sweden, who started ESAB, invented and patented the covered electrode. This electric welding process made strong welds of excellent quality.

World War I caused a major surge in the use of welding processes, with the various military powers attempting to determine which of the several new welding processes would be best. The British primarily used arc welding, even constructing a ship, the Fulagar, with an entirely welded hull. The Americans were more hesitant, but began to recognize the benefits of arc welding when the process allowed them to repair their ships quickly after a German attack in the New York Harbor at the beginning of the war. Arc welding was first applied to aircraft during the war as well, as some German airplane fuselages were constructed using the process.

During the 1920s, major advances were made in welding technology, including the introduction of automatic welding in 1920, in which electrode wire was fed continuously.

Shielding gas became a subject receiving much attention, as scientists attempted to protect welds from the effects of oxygen and nitrogen in the atmosphere. **Porosity and brittleness** were the primary problems, and the solutions that developed included the use of hydrogen, argon, and helium as welding atmospheres.

During the following decade, further advances allowed for the welding of reactive metals like aluminum and magnesium. This, in conjunction with developments in automatic welding, alternating current, and **flux**es fed a major expansion of arc welding during the 1930s and then during World War II.

A significant invention was defined in a patent by Alexander, filed in December 1924, and became known as the Atomic Hydrogen Welding Process. It looks like MIG welding but hydrogen is used as the shielding gas which also provides extra heat. A major innovation was described in a patent that defines the Submerged Arc Process by Jones, Kennedy and Rothermund. This patent was filed in October 1935 and assigned to Union Carbide Corporation.

Russell Meredith working at Northrop Aircraft Company in 1939-1941 invented the TIG process. This new process was called "Heliarc" as it used an electric arc to melt the base material and helium to shield the **molten puddle**. Mr.Jack Northrop's dream was to build a magnesium airframe for a lighter, faster warplanes and his welding group invented the process and developed the first TIG torches. The patents were sold to Linde who developed a number of torches for different applications. They also developed procedures for using Argon which was more available and less expensive than Helium.

In 1957, the flux-cored arc welding process debuted, in which the self-shielded wire electrode could be used with automatic equipment, resulting in greatly increased welding speeds, and that same year, plasma arc welding was invented. Electroslag welding was released in 1958, and it was followed by its cousin, electrogas welding, in 1961.

Other recent developments in welding include the 1958 breakthrough of electron beam welding, making deep and narrow welding possible through the concentrated heat source. Following the invention of the laser in 1960, laser beam welding debuted several decades later, and has proved to be especially useful in high-speed, automated welding. Both of these processes, however, continue to be quite expensive due the high cost of the necessary equipment, and this has limited their applications.

Vocabulary

forge	выковывать, ковать
oxyacetylene	1) автогенный 2) кислородно-ацетиленовый
porosity	пористость
brittleness	хрупкость
shielding gas	защитный газ
welding rod	сварочный пруток
MIG	metal inert gas welding сварка металлическим электродом в инертном газе

torch	горелка
molten pool/puddle	сварочная ванна, ванна жидкого металла
impurities	примеси

4 Find equivalents for the following words combinations in the text.

Торговое судоходство, открытая печь, военный самолет, открытый горн, источник тепла, признавать преимущества, высокая стоимость, приводить к увеличению скорости сварки, оказаться особенно полезным.

5 Fill in the table with the scientists' names and their inventions from the lists below.

Scientists: Edmund Davy; A. P. Strohmenger; Jones, Kennedy and Rothermund; Benardos; C.J. Holslag; Oscar Kjellberg; Alexander; Nikolai Slavyanov and C.L. Coffin.

Inventions: discovered acetylene; invented the electric arc; developed metal electrode; brought a coated metal electrode; invented and patented the covered electrode; invented alternating current; developed Submerged Arc Welding; patented Atomic Hydrogen Welding process.

Date	Scientist	Invention
1540	Vannoccio Biringuccio	described forging operation
1800	Sir Humphrey Davy;	
1800s.		
1836		
1881		demonstrated the welding process with carbon electrode
1900		
1904		
1919		
1935		
1924		

6 Say if the following is true or false. Correct the false statements.

1. Arc welding was used to build the Iron pillar in Delhi, India.
2. The discovery of acetylene made it possible to achieve higher heating temperatures.
3. The first electrode used in welding was a covered one.
4. Oxygen is used as shielding gas in TIG welding.
5. The TIG process made it possible to construct planes faster.

7 Answer the following question on the text.

1. Which process was developed earlier, MIG or TIG?
2. Why is rod added in carbon electrode welding?
3. What is the difference between the Atomic Hydrogen Welding process and the MIG process?
4. What kind of gas was first used to shield the molten puddle?
5. Is tungsten electrode consumable?

8 Translate the following sentences from Russian into English.

1. Ковка – первый в истории метод соединения металлов, при котором было необходимо нагреть соединяемые металлы до высокой температуры на открытом пламени.
2. Открытие ацетилена и соединение его с кислородом позволило значительно повысить температуру нагрева свариваемых металлов.
3. Российский изобретатель Бенардос впервые использовал неплавящийся угольный электрод.
4. Использование электрода с покрытием значительно повысило качество получаемых сварных соединений.
5. Изобретение дуговой сварки под флюсом позволило ускорить строительство торговых судов.
6. При дуговой сварке вольфрамовым электродом в качестве инертного газа использовался гелий, который позднее был заменен более дешевым в получении аргоном.

Reading 2

9 *Read the text* **From the History of Welding** *and refer the statements 1-4 to each of the passages of the text A-D*

1. Application of welding techniques is decreasing nowadays.
2. Welding originated from the attempts to shape metal into useful forms.
3. Resistance welding is one of the earliest types of joining metals.
4. Industrial development in the 1950-s expedited (ускорять) the advance of welding technologies.

From the History of Welding

A Welding is a technique used for **joining** metallic parts usually through the application of heat. This technique was discovered during efforts to manipulate iron into useful shapes. Welded blades were developed in the first millennium AD, the most famous being those produced by Arab **armour**ers at Damascus, Syria. The process of **carburization** of iron to produce hard steel was known at this time, but the resultant steel was very **brittle**. The welding technique - which involved **interlayering** relatively soft and tough iron with **high-carbon** material, followed by **hammer forging -** produced a strong, tough blade.

B In modern times the improvement in iron-making techniques, especially the introduction of **cast iron**, restricted welding to the **blacksmith** and the **jeweler**. Other joining techniques, such as fastening by bolts or rivets, were widely applied to new products, from bridges and railway engines to kitchen utensils.

C Modern fusion welding processes are an outgrowth of the need to obtain a continuous **joint** on large steel plates. **Riveting** had been shown to have disadvantages, especially for an enclosed container such as a **boiler**. Gas welding, arc welding, and **resistance** welding all appeared at the end of the 19th century. The first real attempt to adopt welding processes on a wide scale was made during World War I. By 1916 the **oxyacetylene** process was well developed, and the welding techniques employed then are still used. The main improvements since then have been in equipment and safety. Arc welding, using a **consumable** electrode, was also introduced in this period, but the bare wires initially used produced brittle welds. A solution was found by wrapping the **bare** wire with **asbestos** and an entwined aluminum wire. The modern electrode, introduced in 1907, consists of a bare wire with a complex **coating** of minerals and metals. Arc welding was not universally used until World War II, when the urgent need for rapid means of construction for shipping, power plants, transportation, and structures spurred the necessary development work.

D Resistance welding, invented in 1877 by Elihu Thomson, was accepted long before arc welding for **spo**t and **seam** joining of **shee**t. **Butt** welding for chain making and joining **bar**s and **rod**s was developed during the 1920s. In the 1940s the tungsten-inert gas process, using a nonconsumable **tungsten** electrode to perform fusion welds, was introduced. In 1948 a new gas-shielded process utilized a wire electrode that was consumed in the weld. More recently, electron-beam welding, laser welding, and several solid-phase processes such as diffusion **bonding**, friction welding, and ultrasonic joining have been developed.

Vocabulary

armour	броня
carburization	науглероживание
interlayering	чередование слоев
high-carbon	высокоуглеродистый
hammer forging	свободная ковка на молоте
cast iron	чугун
blacksmith	кузнец
jeweler	ювелир
riveting	производить клёпку
boiler	паровой котёл, бойлер
oxyacetylene	ацетилено-кислородный
consumable	расходуемый
bare	непокрытый
coating	покрытие
spot	точечная
seam	роликовая
sheet	лист
butt	стыковая
tungsten	вольфрам
bonding	соединение, (с)крепление, связывание

10 Find the English equivalents for the following word combinations in the text.

Сварочная технология, твердое железо, кухонная утварь, листовая сталь, сложное покрытие, алюминиевая проволока, острая необходимость, проволока без покрытия.

11 Say if the following is true or false. Correct the false sentences.

1. Only heat is used for joining metallic parts in welding.
2. The process of carburization of iron is rather new.
3. The blacksmith and the jeweler continue to use welding techniques in their work.
4. Welding is the only technique of joining metallic parts.
5. The modern electrode consists of a bare wire with asbestos.
6. Arc welding was not used after World War II.
7. Diffusion bonding and friction welding are solid-phase processes.
8. Riveting is now widely used for producing an enclosed container such as a boiler.

12 Answer the following questions.

1. What is welding?
2. How was welding discovered?
3. Who were the first welders?
4. What did the first welding technique for making blades involve?
5. Did the improvement in iron-making techniques conduce to the development of welding?
6. Is it efficient to apply riveting for making boilers?
7. When did gas, arc and resistance welding appear?
8. What was the quality of the welds produced by the arc welding using bare wires like?
9. What does the coating of the modern electrode consist of?
10. What are the years 1877, 1916, and 1948 remarkable for in terms of welding?

13 Translate from Russian into English.

1. Арабских оружейников, изготавливавших кованые клинки, можно считать первыми сварщиками.
2. Появление методов сварки плавлением было обусловлено необходимостью производства изделий из крупнолистовой стали.
3. Впервые сварка стала использоваться в массовом производстве во время первой мировой войны.
4. Вторая мировая война ускорила внедрение электродуговой сварки.
5. Современный сварочный электрод имеет сложное покрытие, состоящее из композитных материалов.
6. Помимо сварки, клепка и болтовые соединения являются основными методами соединения металлов.

Writing

14 Write a short report on the history of welding mentioning

Dates: first millennium AD, 1540, 1800, 1836, 1881, , 1877, 1881, 1892, 1900, 1904, 1907, 1924, 1935, 1948.
Names: Alexander, Jones, Kennedy and Rothermund, Morehead and Wilson, Oscar Kjellberg, Benardos, Russell Meredith, Edmund Davy, Nikolai Slavyanov, C.L. Coffin, Vannoccio Biringuccio, Sir Humphrey Davy.
Places: Syria, Russia, Sweden, the US, Britain;
Inventions: modern electrode, resistance welding, oxyacetylene process, MIG, TIG, atomic hydrogen welding process, submerged arc welding, carbon electrode.

.**Project work**

15 Read about ***The ASME Code.*** *Find out the content of the ASME code. Make a presentation or a report.*

The ASME Code

In the late 1920s and early 1930s, the welding of pressure vessels came on the scene. Welding made possible a quantum jump in pressure attainable because the process eliminated the low structural efficiency of the riveted joint. Welding was widely utilized by industry as it strove to increase operating efficiencies by the use of higher pressures and temperatures, all of which meant thick-walled vessels. But before this occurred, a code for fabrication was born from the aftermath of catastrophe.

On April 27, 1865, the steamboat Sultana blew up while transporting 2200 passengers on the Mississippi River. The cause of the catastrophe was the sudden explosion of three of the steamboat's four boilers, and up to 1500 people were killed as a result. Most of the passengers were Union soldiers homeward bound after surviving Confederate prison camps. In another disaster on March 10, 1905, a fire tube boiler in a shoe factory in Brockton, Mass., exploded, killing 58, injuring 117 and causing damages valued at $250,000. These two incidents, and the many others between them, proved there was a need to bring safety to boiler operation. So, a voluntary code of construction went into effect in 1915 - the ASME Boiler Code.

As welding began to be used, a need for nondestructively examining those welds emerged. In the 1920s, inspectors tested welds by tapping them with hammers, then listening to the sound through stethoscopes. A dead sound indicated a defective weld. By 1931, the revised Boiler Code accepted welded vessels judged safe by radiographic testing. By this time, magnetic particle testing was used to detect surface cracks that had been missed radiographic testing. By this time, magnetic particle testing was used to detect surface cracks that had been missed by radiographic inspection. In his history of the ASME Code, A. M. Greene, Jr., referred to the late 1920s and early 1930s as "the great years." It was during this period that **fusion welding** received widespread acceptance. Nowadays, thousands of individuals who make their living in welding live and breathe the ASME Code every minute of the working day.

In 1977, Leonard Zick, chairman of the main committee of the ASME Code, said, "It's more than a code; the related groups make up a safety system. Our main objective is to provide requirements for new construction of pressure-related items that, when followed, will provide safety to those who use them and those who might be affected by their use. "

Reading 3

16 You will read four texts about **Welding's Vital Part in Major American Historical Events.** *Before you read suggest your answers to the following questions.*

1. How can welding influence the history of a country?
2. In what fields of industry, in your opinion, is welding especially important?
3. What modern machines and structures cannot be produced without welding processes?
4. What welding process, arc or gas ones, has played a more important part in developing new technologies?

17 Look through the texts and find out what the following figures relate to.

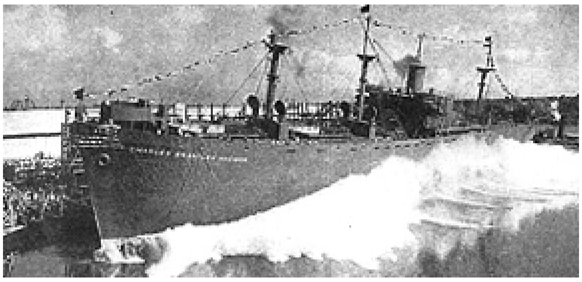
140 20 5171 **2200** 1945 525 531 2710 120 176,000 500,000 586,000 17,000 80 373 500 52 48,6

***Model**:* 2200 - 2200 passengers were killed on the Mississippi River when the steamboat Sultana blew up.

18 Divide into four groups, each group reading one of the four texts. Fill in the table below for your text.

Time period	Branch of Industry	Types of welding	Achievements

Welding's Vital Part
in Major American Historical Events



1 Shipbuilding

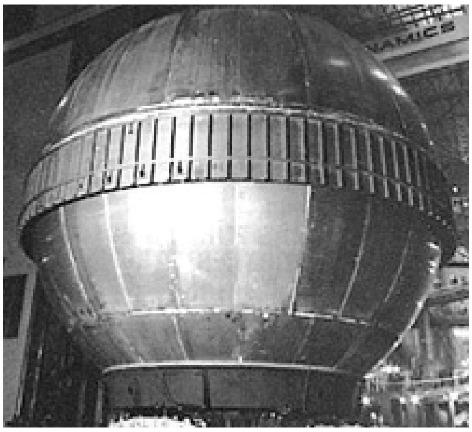
The finest hours for U.S. shipbuilding were during World War II when 2710 Liberty ships, 531 Victory ships and 525 T-2 tankers were built for the **war effort**. Through 1945, some 5171 vessels of all types were constructed to American Bureau of Shipping (ABS) class during the Maritime Commission wartime shipbuilding program. At this time in shipbuilding history, welding was replacing **riveting** as the main method of assembly.

The importance of welding was emphasized early in the war when President Roosevelt sent a letter to Prime Minister Winston Churchill, who is said to have read it aloud to the members of Britain's House of Commons. The letter read in part, "Here there had been developed a welding technique which enables us to construct standard merchant ships with a speed unequaled in the history of merchant shipping."

The technique the President was referring to was undoubtedly submerged arc welding, which was capable of joining steel plate as much as 20 times faster than any other welding process at that time.

During this period of assimilation, eight Liberty ships were lost due to a problem called **brittle fracture**. At first, many blamed welding, but history would soon prove that the real cause of brittle fracture was steels that were **notch sensitive** at operating temperatures. The steel was found to have high sulfur and phosphorus contents. On more than 1400 ships, crack **arrestors** were used to prevent **crack propagation**. No crack was known to grow past an arrestor. This safeguard helped reduce casualties from 140 to 20 per month.

2 LNG Tankers



A triumph of the code was the huge aluminum spheres built by General Dynamics in Charleston, S.C. They were built to criteria established by the U.S. Coast Guard and were based on Section VIII, Division 1, of the ASME Code.

At about 2 a.m. on October 2, 1976, the first welded aluminum sphere for a liquefied natural gas tanker was rolled out of a building in Charleston, then moved over to a special stand for final hydropneumatic testing.

It soon passed the test with flying colors.The sphere itself weighed 850 tons and measured 120 ft (36 m) in diameter. Each sphere consisted of more than 100 precisely machined plates, "orange peel" in shape. The plates were gas metal arc welded together using 7036 lb (3166 kg) of filler metal. Total length of the welds on each sphere was 48.6 miles. Completed spheres were barged along the coast and delivered onto steel tankers under construction at General Dynamics' shipyard in Quincy, Mass. This type of LNG tanker was based on the Moss-Rosenberg design from Norway.

At General Dynamics' facility in Charleston, 80% of the metalworking manhours were spent welding. Much of the filler metal deposited in Charleston was 5183 aluminum. The vertical joints were welded using special equipment from Switzerland in which the operator rode in a custom-designed chair alongside the welding arc. At this distance, he was able to monitor the weld and observe the oscillation of the 1Z.5 -mm diameter filler metal. Actual welding was controlled remotely. About 30 weld passes were required for each joint.

The massive equatorial ring was welded outdoors. In this setup, nine heavily machined, curved aluminum extrusions had to be welded together. To do it, 88 GMA weld passes were made from the outside and 60 more from the inside.

3 The Alaska Pipeline

Perhaps no single welding event in history ever received so much attention as did the Alaska Pipeline. Crews of seasoned welders braved Alaska's frigid terrain to weld this large-diameter pipeline, from start to finish. At one point, 17,000 people were working on the pipeline - 6% of the total population of Alaska. The entire pipeline only disturbed about 12 square miles of the 586,000 square miles of the state of Alaska.

Welders were called upon to handle and weld a new steel pipe thicker and larger than most of them had ever encountered before, using electrodes also new to most. And, the requirements were the stiffest they had ever seen.

The U.S. Department of the Interior and a new pipeline coordinating group representing the state of Alaska instituted some changes. So, the original specifications for **field welding** were tossed, replaced by much stiffer requirements for **weld toughness**. Instead of the conventional pipeline welding electrode planned originally for the bulk of field welding, the new requirements required higher quality. The only electrode the engineers could find that met the new requirements was an E8010-G filler metal from Germany, so it was soon flown over by the **planeload**. Some of the Pipeline Welders Union out of Tulsa, Okla., then welding in Alaska, had used this electrode while working on lines in the North Sea, but most welders were seeing it for the first time.

One of the requirements was 100% **X-ray inspection** of all welds. The films were processed automatically in vans that traveled alongside the welding crews.

Welders worked inside protective aluminum enclosures intended to protect the weld joint from the wind. Lighting inside the enclosures enabled welders to see what they were doing during Alaska's dark winter.

On the main pipeline, preheat and the heat between weld passes was applied at first by spider-ring burners. **Induction heating** was used later during construction.

4 High-Rise Construction

About 30 years ago, steel construction went into orbit. The 100-story John Hancock Center in Chicago and the 110-story twin towers of New York's World Trade Center were under construction. Above ground, the World Trade Center required some 176,000 tons of fabricated **structural steel**. The Sears Tower came later. Bethlehem Steel Corp. had received orders for 200,000 tons of **rolled steel** products for the South Mall complex in Albany, N.Y. Allied Structural Steel Co. was reported to have used multiple-electrode gas metal arc welding in the fabrication of the First National Bank of Chicago Building.

In a progress report on the erection of the critical corner pieces for the first 22 floors of the 1107-ft (332-m) high John Hancock Center, an Allied Structural Steel spokesman said various welding processes were being used in that portion of the *high-rise building*. More than 12,000 tons of structural steel were used in that section. Webs and flanges for each *interior H column* were made up of A36 steel plate with thicknesses up to 6172 in. (16.5 cm). The long **fillet weld**s at the web-to-flange **contact face**s were made using the **submerged arc** process, while the box consumed in shop fabrication for this building, while 165,000 lb (74,250 kg) of weld metal was consumed during field erection. Weld *metal consumption* in shop fabrication for the U.S. Steel Building in Pittsburgh, Pa., reached 609,000 lb (274,050 kg).

During this same period, Kaiser Steel Corp. had used the consumable guide version of electroslag welding to deposit 24,000 welds in the Bank of America world *headquarters building* in San Francisco. At the time, this building was regarded as the tallest *earthquake-proof* structure ever erected on the West Coast. In terms of welding, one of the most intensive structures built during this period was NASA's Vertical Assembly Building on Merritt Island, Fla. Shop-welded sections for this giant structure consumed 830,000 lb (373,500 kg) of weld metal.

For the World Trade Center, Leslie E. Robertson, a partner in charge of the New York office of Skilling, Helle, Christiansen, Robertson, said a computer was used to produce the drawing lists, beam schedules, column details and all schedules for exterior wall panels. Millions of IBM cards were then sent to every fabricator. These cards gave fabricators the width, length, thickness and *grade* of steel of every plate and section in all of the columns and panels. "In addition," he said, "the fabricators are given all of the requirements of every weld needed to make up the columns and panels. Many of these cards are used as **equable** to the production of drawings. They are sent directly from the designer to the fabricators. Draftsmen never become involved."

Vocabulary

war effort	военная экономика
brittle fracture	хрупкий излом
notch	зубец, вырез, паз, пропил, прорез
crack propagation	развитие трещин
field welding	сварка в полевых условиях, сварка при монтаже
toughness	твердость
planeload	полная загрузка самолета
X-ray inspection	рентгенодефектоскопия
induction heating	индукционный нагрев
structural steel	конструкционная сталь
rolled steel	стальной прокат
fillet weld	угловой сварной шов
contact face	поверхность контакта

Speaking

19 Use the information in the table as a plan and speak about the achievement you have read about to the class.

Revision

Name:

- a method to protect welds from the effects of oxygen and nitrogen in the atmosphere
- the inventions in welding attributed to Russian scientists
- the code providing safety for construction of pressure-related items
- some recently developed types of welding

PART 3. WELDING PROCESSES & EQUIPMENT

Lead-in

1 There are processes similar to welding which a welder should know about. Read the definitions of metal joining processes (1-6) and supply them with Russian equivalents from the list (a-f).

a) резка
b) пайка мягким (легкоплавким) припоем
c) свинцевание
d) клепка
e) лужение
f) пайка твердым припоем резка

1. ***Soldering:*** Bonding by melting a soft metal to the surface of pieces to be joined. Low temperature. Good for joining dissimilar materials. Most common solders are lead-tin alloys.
2. ***Tinning:*** A soldering process, where the surface of a metal is coated with solder.
3. ***Leading:*** A form of soldering, solder is used to fill in the surface of metal.
4. ***Brazing:*** Similar to soldering, but uses a higher temperature to fuse the filler metal to the work pieces. Stronger bond. (Includes "Silver Soldering") Work heated to pre-melt temperatures.
5. ***Cutting:*** Work is heated to melting point and beyond, and "cut" by oxidizing metal. (Literally burning it away).
6. ***Riveting:*** A process of fastening with a rivet which is a heavy pin having a head at one end and the other end being hammered flat after being passed through holes in the pieces that are fastened together.

2 Remember the definition of welding and say what the main difference between welding and related metal joining processes is.

Reading 1

3 You will read the text **Basic Principles of Welding.**
Before you read list all the ways of generating heat for welding.

Ways of Generating Heat for Welding
1. Electric arc
…
…

4 *Read the text and answer the questions.*

1. What is a weld?
2. How can the heat be supplied for welding?
3. Is pressure employed in solid-phase processes?
4. What does an arc column consist of?
5. How is heat applied during welding?
6. What is the role of inert atmospheres?
7. What can make a joint brittle while welding?
8. What does the weld metal comprise in arc welding?
9. What is the base metal influenced by?
10. How can residual stress in welded structures be controlled?

Basic Principles of Welding

A weld can be defined as a **coalescence** of metals produced by heating to a suitable temperature with or without the application of pressure, and with or without the use of a filler material.

In fusion welding a heat source generates sufficient heat to create and maintain a **molten pool** of metal of the required size. The heat may be supplied by electricity or by a **gas flame**. Electric resistance welding can be considered fusion welding because some molten metal is formed.

Solid-phase processes produce welds without melting the base material and without the addition of a filler metal. Pressure is always employed, and generally some heat is provided. Frictional heat is developed in **ultrasonic** and **friction** joining, and **furnace** heating is usually employed in **diffusion** bonding.

The electric arc used in welding is a **high-current, low-voltage discharge** generally in the range 10–2,000 amperes at 10–50 volts. An **arc column** is complex but, broadly speaking, consists of a cathode that emits electrons, a gas plasma for current conduction, and an anode region that becomes comparatively hotter than the cathode due to electron bombardment. Therefore, the electrode, if consumable, is made positive and, if nonconsumable, is made negative. A **direct current (dc)** arc is usually used, but **alternating current (ac)** arcs can be employed.

Total energy input in all welding processes exceeds that which is required to produce a joint, because not all the heat generated can be effectively utilized. Efficiencies vary from 60 to 90 percent, depending on the process; some special processes deviate widely from this figure. Heat is lost by conduction through the base metal and by radiation to the surroundings.

Most metals, when heated, react with the atmosphere or other nearby metals. These reactions can be extremely detrimental to the properties of a welded joint. Most metals, for example, rapidly oxidize when molten. A **layer** of oxide can prevent proper bonding of the metal. **Molten-metal droplets** coated with oxide become entrapped in the weld and make the joint brittle. Some valuable materials added for specific properties react so quickly on exposure to the air that the metal deposited does not have the same composition as it had initially. These problems have led to the use of **fluxes** and **inert atmospheres**.

In fusion welding the flux has a protective role in facilitating a controlled reaction of the metal and then preventing oxidation by forming a blanket over the molten material. Fluxes can be active and help in the process or inactive and simply protect the surfaces during joining.

Inert atmospheres play a protective role similar to that of fluxes. In gas-shielded metal-arc and gas-shielded tungsten-arc welding an inert gas — usually argon—flows from an **annulus** surrounding the **torch** in a continuous stream, displacing the air from around the arc. The gas does not chemically react with the metal but simply protects it from contact with the oxygen in the air.

The metallurgy of metal joining is important to the functional capabilities of the joint. The arc weld illustrates all the basic features of a joint. Three zones result from the passage of a welding arc: (1) the weld metal, or fusion zone, (2) the heat-affected zone, and (3) the unaffected zone. The weld metal is that portion of the joint that has been melted during welding. The heat-affected zone is a region adjacent to the weld metal that has not been welded but has undergone a change in microstructure or mechanical properties due to the heat of welding. The unaffected material is that which was not heated sufficiently to alter its properties.

Weld-metal composition and the conditions under which it freezes (solidifies) significantly affect the ability of the joint to meet service requirements. In arc welding, the weld metal comprises **filler mater**ial plus the **base metal** that has melted. After the arc passes, rapid cooling of the weld metal occurs. A one-pass weld has a cast structure with **columnar grains** extending from the edge of the **molten pool** to the centre of the weld. In a multipass weld, this cast structure may be modified, depending on the particular metal that is being welded.

The base metal adjacent to the weld, or the heat-affected zone, is subjected to a range of temperature cycles, and its change in structure is directly related to the peak temperature at any given point, the time of exposure, and the cooling rates. The types of base metal are too numerous to discuss here, but they can be grouped in three classes: (1) materials unaffected by welding heat, (2) materials hardened by structural change, (3) materials hardened by **precipitation** processes.

Welding produces stresses in materials. These forces are induced by contraction of the weld metal and by expansion and then contraction of the heat-affected zone. The unheated metal imposes a restraint on the above, and as contraction predominates, the weld metal cannot contract freely, and a stress is built up in the joint. This is generally known as **residual stress**, and for some critical applications must be removed by heat treatment of the whole fabrication. Residual stress is unavoidable in all welded structures, and if it is not controlled bowing or distortion of the weldment will take place. Control is exercised by welding technique, jigs and fixtures, fabrication procedures, and final heat treatment.

Vocabulary

coalescence	соединение, слипание, сращение
molten pool	ванна расплавленного металла, сварочная ванна
gas flame	газовое пламя
solid-phase	твёрдая фаза
ultrasonic	ультразвуковой
friction	трение
furnace	печь
diffusion	1) рассеивание 2) диффузия
high-current	сильноточный
low-voltage	низковольтный, низкого напряжения
discharge	разряд
arc column	столб дуги
direct current (dc)	постоянный ток
alternating current	(ac)переменный ток
layer	слой, пласт, ряд
molten-metal droplet	капля жидкого металла
inert atmosphere	инертная среда
annulus	тех. узкое кольцо (зазор и т. п.)
torch	сварочная горелка (для автоматической сварки – головка)
base metal	основной металл
grain	зерно
precipitation	осаждение
residual stress	остаточное напряжение

5 Find the English equivalents for the following words and word combinations.

Расплавленный металл, необходимый размер, не нагретый металл, механические свойства, максимум температуры, защищать поверхности, быстрое охлаждение, осуществлять контроль, препятствовать окислению, вступать в химическую реакцию, термообработка, бомбардировка электронами, зона термического [теплового] воздействия, общая потребляемая энергия.

6 Complete the following sentences.

1. A characteristic feature of fusion welding is:
a) molten metal b) low-voltage discharge c) inert atmosphere
2. Furnace heating is usually employed in
a) friction joining b) diffusion bonding c) ultrasonic joining
3. The consumable electrode is made
a) negative b) positive c) neither
4. Total energy input in all welding processes is
a) is greater than required to produce a joint b) is smaller than required to produce a joint c) equals to required to produce a joint
5. Reactions of most metals with the atmosphere or other nearby metals can
1) improve the properties of a welded joint b) make the properties of a welded joint worse c) never influence the properties of a welded joint
6. The most common gas used in gas-shielded metal-arc and gas-shielded tungsten-arc welding is
a) argon b) oxygen c) carbon dioxide
7. If not controlled, residual stress results in
a) precipitation processes in welded structures, b) freezing of the weld-metal c) bowing or distortion of the weldment.

7 Say if the following sentences are true or false.

1. There is always a welding pool in solid-phase welding processes.
2. Total energy input in all welding processes is greater than needed to produce a weld.
3. Reactions of metals with the atmosphere or other nearby metals are favorable to the properties of a welded joint.
4. Fluxes and inert atmospheres play a protective role and prevent oxidation.
5. The heat-affected zone is a region with unaltered properties.
6. Residual stress is present in all welded structures.

Writing

8 Write a short report on the subject below.

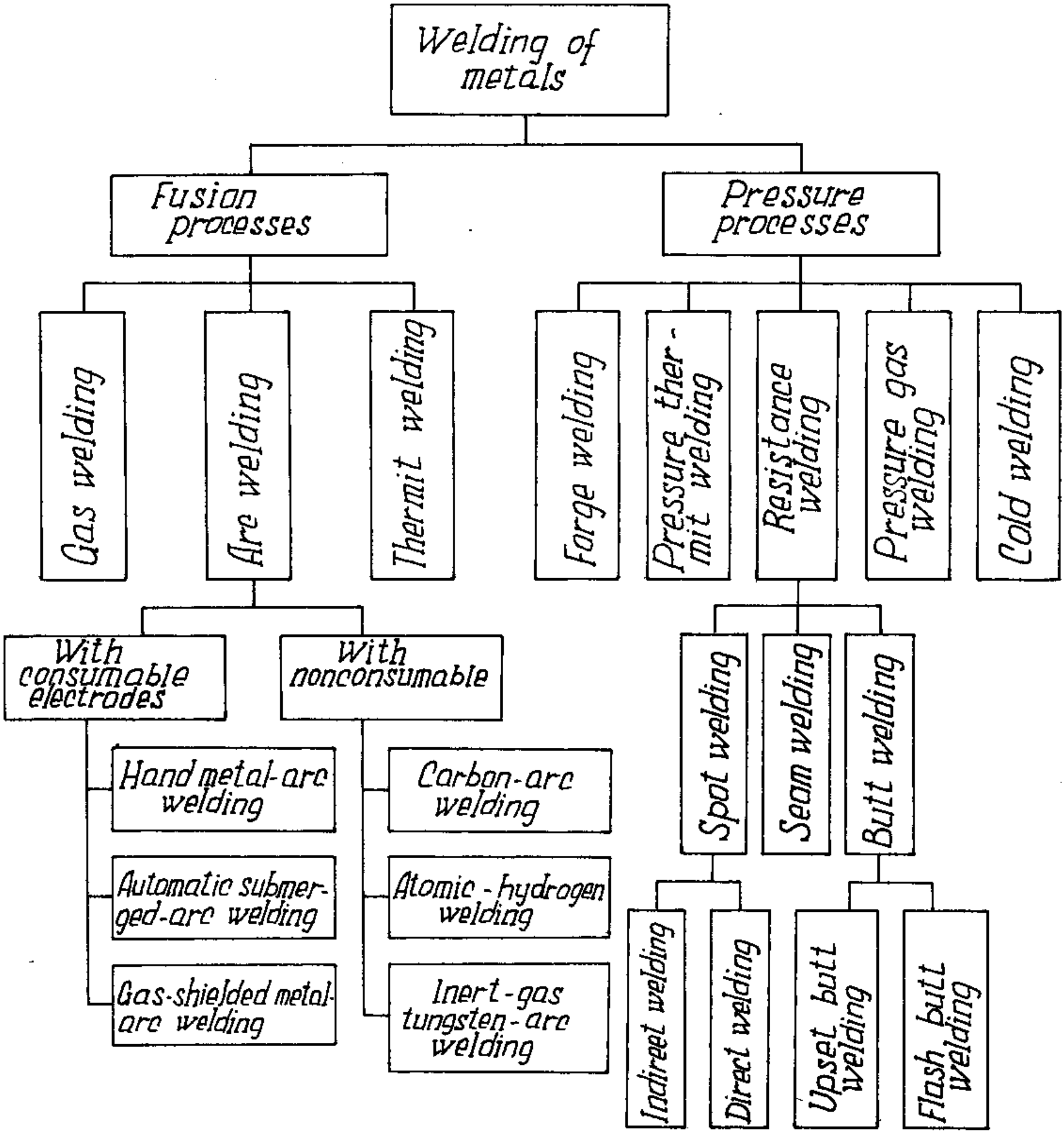
Function of Fluxes and Inert Atmosphere in Welding

Reading and speaking

9 Study the ***Master Chart of the Principal Welding Processes (Chart 1)*** *and complete the sentences.*

1. The two basic welding processes are ... .
2. The fusion processes **consist of** … .
3. Among these, arc welding **can be accomplished** …
4. Arc welding with consumable electrodes **includes the following types… .**
5. Carbon arc welding, atomic hydrogen welding, inert gas tungsten arc welding **refer to** … .

10 Describe the classification of ***pressure processes****. Use the verbs in bold from the previous exercise.*



Welding of metals
Fusion processes
Pressure processes
Gas welding
Arc welding
Thermit welding
Forge welding
Pressure thermit welding
Resistance welding
Pressure gas welding
Cold welding
With consumable electrodes
With nonconsumable
Hand metal-arc welding
Automatic submerged-arc welding
Gas-shielded metal-arc welding
Carbon-arc welding
Atomic - hydrogen welding
Inert-gas tungsten-arc welding
Spot welding
Seam welding
Butt welding
Indirect welding
Direct welding
Upset butt welding
Flash butt welding

Reading 2

11 You will read the text **Alternative Types of Welding.** *Before you read suggest your answers to the following questions.*

1. What is the difference between the principle (“traditional”) and alternative types of welding?
2. Why are traditional welding processes not sufficient?

12 Match welding types (1-6) with their description (A-F). Then read the text and check your answers.

1. Cold welding	A. Light energy is used to weld parts together.
2. Friction welding	B. The weld is formed at the expense of the applied pressure at a high temperature for a long period of time.
3. Laser welding	C. Vibration is used to generate heat necessary to produce a weld. e
4. Diffusion bonding	D. The heat to accomplish the joint is generated by rotation.
5. Ultrasonic welding	E. The most important factor to accomplish the weld is pressure. No heat is applied.
6. Explosive welding	F. Rapid plastic deformation of the welded materials is caused by detonation.

Alternative Types of Welding

Cold welding

Cold welding, the joining of materials without the use of heat, can be accomplished simply by pressing them together. Surfaces have to be well prepared, and pressure sufficient to produce 35 to 90 percent deformation at the joint is necessary, depending on the material. **Lapped joints** in sheets and cold-**butt** welding of wires constitute the major applications of this technique. Pressure can be applied by **punch presses**, rolling stands, or **pneumatic tooling**. Pressures of 1,400,000 to 2,800,000 kilopascals (200,000 to 400,000 pounds per square inch) are needed to produce a joint in aluminum; almost all other metals need higher pressures.

Friction welding

In friction welding two work pieces are brought together under load with one part rapidly revolving. Frictional heat is developed at the interface until the material becomes plastic, at which time the rotation is stopped and the load is increased to consolidate the joint. A strong joint results with the plastic deformation, and in this sense the process may be considered a variation of pressure welding. The process is self-regulating, for, as the temperature at the joint rises, the friction coefficient is reduced and overheating cannot occur. The machines are almost like lathes in appearance. Speed, force, and time are the main variables. The process has been automated for the production of axle casings in the automotive industry.

Laser welding

Laser welding is accomplished when the light energy emitted from a laser source focused upon a work-piece to fuse materials together. The limited availability of lasers of sufficient power for most welding purposes has so far restricted its use in this area. Another difficulty is that the speed and the thickness that can be welded are controlled not so much by power but by the thermal conductivity of the metals and by the avoidance of metal vaporization at the surface. Particular applications of the process with very thin materials up to 0.5 mm (0.02 inch) have, however, been very successful. The process is useful in the joining of miniaturized electrical **circuitry**.

Diffusion bonding

This type of bonding relies on the effect of applied pressure at an elevated temperature for an appreciable period of time. Generally, the pressure applied must be less than that necessary to cause 5 percent deformation so that the process can be applied to **finished** machine parts. The process has been used most extensively in the aerospace industries for joining materials and shapes that otherwise could not be made—for example, multiple-**fin**ned channels and **honeycomb** construction. Steel can be diffusion bonded at above 1,000 ° C (1,800 ° F) in a few minutes.

Ultrasonic welding

Ultrasonic joining is achieved by clamping the two pieces to be welded between an **anvil** and a vibrating probe or sonotrode. The vibration raises the temperature at the interface and produces the weld. The main variables are the clamping force, power input, and welding time. A weld can be made in 0.005 second on thin wires and up to 1 second with material 1.3 mm (0.05 inch) thick. Spot welds and continuous seam welds are made with good reliability. Applications include extensive use on lead bonding to integrated circuitry, transistor canning, and aluminum can bodies.

Explosive welding

Explosive welding takes place when two plates are impacted together under an explosive force at high velocity. The lower plate is laid on a firm surface, such as a heavier steel plate. The upper plate is placed carefully at an angle of approximately 5° to the lower plate with a sheet of explosive material on top. The charge is detonated from the hinge of the two plates, and a weld takes place in microseconds by very rapid plastic deformation of the material at the interface. A completed weld has the appearance of waves at the joint caused by a jetting action of metal between the plates.

Vocabulary

cold welding	холодная сварка (в вакууме)
lapped joints	соединение внахлестку
diffusion bonding	диффузное соединение
ultrasonic welding	ультразвуковая сварка
explosive welding	сварка взрывом
butt	стык
anvil	наковальня
honeycomb	пористый
fin	ребро, пластина
finished	готовый, обработанный
integrated circuitry	интегральная схемотехника
pneumatic tooling	пневматический инструмент
punch presses	пресс-штамп

13 Fill in the blanks with the right words (namely, types of welding).

1. …welding is successfully used in manufacture of small elements of electric circuits.
2. Heat is not used in … welding.
3. … is widely used in aerospace industries.
4. Vibration is used in …welding.
5. Plastic deformation is the basic principle in … welding.
6. … welding is impossible without pressure and high temperature.
7. In … welding one of the parts being welded revolves.

14 Translate the following sentences into Russian.

1.При холодной сварке поверхности должны быть тщательно подготовлены.
2. Скорость и толщина свариваемых деталей зависит не столько от мощности лазера, сколько от теплопроводности металла.
3. Этот вид сварки наиболее широко используется в авиакосмической промышленности.
4. Холодная сварка – это сварка без использования тепловой энергии, когда две свариваемые поверхности, обладающие высокой пластичностью, с силой прижимают друг к другу.
5. Использование точечной и шовной сварки позволяет получать сварные соединения высокой прочности.
6. Основными переменными величинами при этом виде сварки является подводимое тепло, время сварки и сила сжатия.
7. Фрикционным разогревом добиваются пластичности материала, затем вращение цапфы останавливают и увеличивают давление для обеспечения сваривания поверхностей.
8. Сварной шов имеет чешуйчатый вид, что является результатом обдува струей сжатого воздуха.

Speaking

15 Choose an alternative welding method for the following applications. Explain your choice.

- to join some electrical wires to form a circuit
- a transistor can
- parts of a plane which have honeycomb construction
- to join two aluminum sheets laid one onto another

Revision

16 In each line of words (1-4) find the odd one out. Explain your choice.

1 low-voltage, gas flame, direct current, discharge
2 gas welding, arc welding, … termit welding, resistance welding
3 friction, torch, flux, filler material
4 fusion, filler, heat-affected, unaffected

PART 4. ARC AND GAS WELDING IN DETAIL

Lead-in

1 Remember the definition and description of arc welding from the previous part. What, in your opinion, makes arc welding one of the two main welding processes so widely applied in modern industry?

Reading 1

2 Study the ways of compression of information in ***Appendix 3****. Read Russian texts(A-D) below and say what type of compression they are.*

A В тексте описываются 2 основных метода сварки неплавящимся электродом: дуговая сварка вольфрамовым электродом *в* защитном газе, отличающаяся стабильностью дуги и, таким образом, обеспечивающая возможность сварки тонких листов металла, и плазменная сварка, более скоростная и применяющаяся для сварки материалов большей толщины. Приводятся типичные сферы применения данных разновидностей сварки.

B В тексте описывается возможное вредное влияние сварки на здоровье человека. Отмечается, что снижение влияния вредных факторов при сварке достигается благодаря применению специальной экипировки и других средств защиты. Особое внимание уделяется предотвращению вредного воздействия на человеческий организм выделяемых газов. Отмечается высокий риск возникновения пожара вследствие использования легковоспламеняющихся материалов и кислорода.

C В тексте приводятся сведения о применяемых в электродуговой сварке различных видах электропитания. Описывается обусловленность выбора различных источников электропитания при ручном и автоматическом режимах сварки. В зависимости от выбранного источника, а также от полярности электрода и основного металла, показываются возможные особенности процесса сварки, что позволяет сделать правильный выбор указанных параметров для получения сварного шва.

D В тексте описаны 3 основных вида сварки с использованием плавящегося электрода: дуговая сварка металлическим покрытым электродом, дуговая сварка металлическим электродом в среде инертного газа и дуговая сварка под флюсом. Подробное описание каждой из данных разновидностей сопровождается перечислением их преимуществ и недостатков, пригодности использования в зависимости от типа свариваемого материала, требований к квалификации сварщика, экономичности, скорости и других параметров.

*Skim the English texts (1-4)**(Power Supplies, Consumable Electrode Method, Non-consumable Electrode Method, Safety Issues)**, and match them and Russian texts (A-D) in the previous activity.*

1 Power Supplies

Fig. 1 A constant current welding power supply capable of AC and DC

To supply the electrical energy necessary for arc welding processes, a number of different power supplies can be used. The most common classification is constant current power supplies and constant voltage power supplies. In arc welding, the voltage is directly related to the length of the arc, and the current is related to the amount of heat input. Constant current power supplies are most often used for manual welding processes such as gas tungsten arc welding and shielded metal arc welding, because they maintain a relatively constant current even as the voltage varies. This is important because in manual welding, it can be difficult to hold the electrode perfectly steady, and as a result, the arc length and thus voltage tend to fluctuate. Constant voltage power supplies hold the voltage constant and vary the current, and as a result, are most often used for automated welding processes such as gas metal arc welding, flux cored arc welding, and submerged arc welding. In these processes, arc length is kept constant, since any fluctuation in the distance between the wire and the base material is quickly rectified by a large change in current. For example, if the wire and the base material get too close, the current will rapidly increase, which in turn causes the heat to increase and the tip of the wire to melt, returning it to its original separation distance.

The type of current used in arc welding also plays an important role in welding. Consumable electrode processes such as shielded metal arc welding and gas metal arc welding generally use direct current, but the electrode can be charged either positively or negatively. In welding, the positively charged anode will have a greater heat concentration, and as a result, changing the polarity of the electrode has an impact on weld properties. If the electrode is positively charged, it will melt more quickly, increasing weld penetration and welding speed. Alternatively, a negatively charged electrode results in more shallow welds. Non-consumable electrode processes, such as gas tungsten arc welding, can use either type of direct current, as well as alternating current. However, with direct current, because the electrode only creates the arc and does not provide filler material, a positively charged electrode causes shallow welds, while a negatively charged electrode makes deeper welds. Alternating current rapidly moves between these two, resulting in medium-penetration welds. One disadvantage of AC, the fact that the arc must be re-ignited after every zero crossing, has been addressed with the invention of special power units that produce a square wave pattern instead of the normal sine wave, making rapid zero crossings possible and minimizing the effects of the problem.

2 Consumable Electrode Methods

One of the most common types of arc welding is shielded metal arc welding (SMAW), which is also known as manual metal arc welding (MMA) or stick welding. Electric current is used to strike an arc between the base material and consumable electrode rod, which is made of steel and is covered with a flux that protects the weld area from oxidation and contamination by producing CO_2 gas during the welding process. The electrode core itself acts as filler material, making a separate filler unnecessary. The process is very versatile, requiring little operator training and inexpensive equipment. However, weld times are rather slow, since the consumable electrodes must be frequently replaced and because slag, the residue from the flux, must be chipped away after welding. Furthermore, the process is generally limited to welding ferrous materials, though special electrodes have made possible the welding of cast iron, nickel, aluminum, copper, and other metals. The versatility of the method makes it popular in a number of applications, including repair work and construction.

Gas metal arc welding (GMAW), also known as metal inert gas (MIG) welding, is a semi-automatic or automatic welding process that uses a continuous wire feed as an electrode and an inert or semi-inert gas mixture to protect the weld from contamination. Since the electrode is continuous, welding speeds are greater for GMAW than for SMAW. However, because of the additional equipment, the process is less portable and versatile, but still useful for industrial applications. The process can be applied to a wide variety of metals, both ferrous and non-ferrous. A related process, flux-cored arc welding (FCAW), uses similar equipment but uses wire consisting of a steel electrode surrounding a powder fill material. This cored wire is more expensive than the standard solid wire and can generate fumes and/or slag, but it permits higher welding speed and greater metal penetration.

Submerged arc welding (SAW) is a high-productivity welding method in which the arc is struck beneath a covering layer of flux. This increases arc quality, since contaminants in the atmosphere are blocked by the flux. The slag that forms on the weld generally comes off by itself, and combined with the use of a continuous wire feed, the weld deposition rate is high. Working conditions are much improved over other arc welding processes, since the flux hides the arc and no smoke is produced. The process is commonly used in industry, especially for large products.

3 Non-Consumable Electrode Methods

Gas tungsten arc welding (GTAW), or tungsten inert gas (TIG) welding, is a manual welding process that uses a non-consumable electrode made of tungsten, an inert or semi-inert gas mixture, and a separate filler material. Especially useful for welding thin materials, this method is characterized by a stable arc and high quality welds, but it requires significant operator skill and can only be accomplished at relatively low speeds. It can be used on nearly all weldable metals, though it is most often applied to stainless steel and light metals. It is often used when quality welds are extremely important, such as in bicycle, aircraft and naval applications. A related process, plasma arc welding, also uses a tungsten electrode but uses plasma gas to make the arc. The arc is more concentrated than the GTAW arc, making transverse control more critical and thus generally restricting the technique to a mechanized process. Because of its stable current, the method can be used on a wider range of material thicknesses than can the GTAW process, and furthermore, it is much faster. It can be applied to all of the same materials as GTAW except magnesium, and automated welding of stainless steel is one important application of the process. A variation of the process is plasma cutting, an efficient steel cutting process. Other arc welding processes include atomic hydrogen welding, carbon arc welding, electroslag welding, electrogas welding, and stud arc welding.

4 Safety Issues

Welding, without the proper precautions, can be a dangerous and unhealthy practice. However, with the use of new technology and proper protection, the risks of injury and death associated with welding can be greatly reduced. Because many common welding procedures involve an open electric arc or flame, the risk of burns is significant. To prevent them, welders wear protective clothing in the form of heavy leather gloves and protective long sleeve jackets to avoid exposure to extreme heat and flames. Additionally, the brightness of the weld area leads to a condition called arc eye in which ultraviolet light causes the inflammation of the cornea and can burn the retinas of the eyes. Goggles and helmets with dark face plates are worn to prevent this exposure, and in recent years, new helmet models have been produced that feature a face plate that self-darkens upon exposure to high amounts of UV light. To protect bystanders, transparent welding curtains often surround the welding area. These curtains, made of a polyvinyl chloride plastic film, shield nearby workers from exposure to the UV light from the electric arc, but should not be used to replace the filter glass used in helmets.

Welders are also often exposed to dangerous gases and particulate matter. Processes like flux-cored arc welding and shielded metal arc welding produce smoke containing particles of various types of oxides. The size of the particles in question tends to influence the toxicity of the fumes, with smaller particles presenting a greater danger. Additionally, many processes produce various gases, most commonly carbon dioxide and ozone, and fumes that can prove dangerous if ventilation is inadequate. Furthermore, because the use of compressed gases and flames in many welding processes pose an explosion and fire risk, some common precautions include limiting the amount of oxygen in the air and keeping combustible materials away from the workplace.

3 Read the texts above and find the English equivalents for the following Russian phrases in the text.

Положительно заряженный анод, остатки флюса, волна типа "синусоида", гармоническая волна/ прямоугольная волна, плавящийся электрод, свариваемые металлы, пересечение нулевого уровня, пленка ПВХ, светофильтры, наплавка, горючие материалы

4 Say if the following statements are true or false. Correct the false sentences.

1. Filler material is always necessary for arc welding.
2. The amount of heat input at the welding point depends on the voltage.
3. Shielded metal arc welding is a consumable electrode process.
4. Consumable welding processes use any type of current.
5. Consumable electrode methods are faster than none-consumable ones.
6. TIG welding requires little operator training.
7. Submerged arc welding is used to weld large work pieces.

5 Answer the following questions on the text.

1. What is arc welding?
2. What kind of current and electrodes are used in arc welding?
3. What is the welded region protected by?
4. Why is constant current power supply most often used for manual welding processes?
5. How does the type of the electrode charge (positive/negative) influence the speed of welding and weld penetration?
6. What problem is related to the use of alternating current in gas tungsten welding?
7. What is the function of flux in shielded metal arc welding?
8. What are the main advantages and disadvantages of manual metal arc welding?
9. Which type of metal arc welding uses a separate filler material?
10. What do the welding protection clothes include?

6 Match the terms (1-10) and their meanings (A-J).

1. Anode	**A** Electromagnetic radiation with a wavelength shorter than that of visible light, but longer than soft X-rays.
2. Ultraviolet (UV) light	**B** Difference of electrical potential between two points of an electrical network, expressed in volts [1]. It is a measure of the capacity of an electric field to cause an electric current in an electrical conductor.
3. Flux	**C** Electrical current whose magnitude and direction vary cyclically, as opposed to direct current, whose direction remains constant.

4. Alternating current (AC)	**D** (from the Greek άνοδος = 'going up') is the electrode in a device that electrons flow out of to return to the circuit. Literally, the path through which the electrons ascend out of an electrolyte solution. The other charged electrode in the same cell or device is the cathode.
5. Oxidation	**E** In metallurgy, a substance which facilitates soldering, brazing, and welding by chemically cleaning the metals to be joined. Common ….s are: ammonium chloride or rosin for soldering tin; hydrochloric acid and zinc chloride for soldering galvanized iron (and other zinc surfaces); and borax for brazing, and welding ferrous metals.
6. Goggles and safety glasses	**F** In metallurgy a ferrous alloy with a minimum of 10% chromium content. The name originates from the fact that it does not stain, corrode or rust as easily as ordinary steel. This material is also called corrosion resistant steel when it is not detailed exactly to its alloy type and grade, particularly in the aviation industry.
7. Toxicity	**G** Loss of an electron by a molecule, atom or ion
8. Stainless steel	**H** also known as arc flash, welder's flash, corneal flash burns, or flash burns, is a painful ocular condition sometimes experienced by welders who have failed to use adequate eye protection. It can also occur due to light from sunbeds, light reflected from snow (known as snow blindness), water or sand. The intense ultraviolet light emitted by the arc causes a superficial and painful keratitis.
9. Arc eye	**I** From Greek τοξικότητα – poisonousness). It can refer to the effect on a whole organism, such as a human or a bacterium or a plant, or to a substructure, such as the liver. By extension, the word may be metaphorically used to describe toxic effects on larger and more complex groups, such as the family unit or "society at large". The skull and crossbones is a common symbol for it.
10. Voltage	**J** Forms of protective eyewear that usually enclose or protect the eye area in order to prevent particulates or chemicals from striking the eyes. They are used in chemistry laboratories and in woodworking. They are often used in snow sports as well, and in swimming. Goggles are often worn when using power tools such as drills or chainsaws to prevent flying particles from damaging the eyes.

7 Translate the following sentences from Russian into English.

1. Зона сварки при электродуговых процессах защищается защитным газом.
2. При сварке с использованием плавящихся электродов используется как постоянный, так и переменный ток.
3.При РДС электрод является присадочным материалом.
4. Благодаря разнообразию способов электродуговой сварки она находит широкое применение в различных отраслях производства.
5. Для защиты сварщиков от ультрафиолетового излучения электрической дуги используются светофильтры.
6. При недостаточной вентиляции газы могут представлять опасность для здоровья.
7. Благодаря отсутствию дыма при дуговой сварке под флюсом условия труда гораздо лучше, чем при других способах электродуговой сварки.
8. В целях предосторожности не следует держать воспламеняющиеся предметы вблизи проведения сварочных работ.

Speaking

*8 Explain to a non-specialist the difference between **consumable electrode method** and **non-consumable electrode methods**.*

Reading 2

9 Below you will find information about some less frequently used arc welding processes. After reading the text, think and say why these processes are less common in industry. Consider their advantages and disadvantages.

Atomic Hydrogen Welding (AHW) is an arc welding process that uses an arc between two metal tungsten electrodes in a shielding atmosphere of hydrogen and without the application of pressure. Shielding is obtained from the hydrogen. Filler metal may or may not be used. In this process, the arc is maintained entirely independent of the work or parts being welded. The work is a part of the electrical circuit only to the extent that a portion of the arc comes in contact with the work, at which time a voltage exists between the work and each electrode.

Carbon Arc Welding (CAW) is a process which produces coalescence of metals by heating them with an arc between a nonconsumable carbon (graphite) electrode and the work-piece. It was the first arc-welding process ever developed but is not used for many applications today, having been replaced by twin carbon arc welding and other variations.

Twin carbon arc welding (TCAW) in which the arc is established between two carbon electrodes

Gas carbon arc welding (CAW-G) no longer has commercial significance

Electroslag welding is a highly productive welding process developed in the United States during the 1930s. It involves the melting of the surfaces of the metal workpieces and the filler metal with a molten slag to cause coalescence. An electric arc is passed through the slag to heat it, but the arc itself is extinguished by the slag. Electroslag welding is commonly used to weld in a vertical orientation, and is particularly popular with steels. In the 1970s, it was used extensively in bridges, ships, and other large metal structures. However, in 1977 the Federal Highway Administration banned its use in welds for some structural members of bridges, due to concerns of weld imperfections and poor properties. Benefits of the process include its high metal deposition rates. Many welding processes require more than one pass for welding thick workpieces, but often a single pass is sufficient for electroslag welding. The process is also very efficient, since joint preparation and materials handling are minimized while filler metal utilization is high. The process is also safe and clean, with no arc flash and low weld splatter or distortion.

Electrogas welding (EGW) is a continuous vertical position arc welding process developed in 1961, in which an arc is struck between a consumable electrode and the workpiece. A shielding gas is sometimes used, but pressure is not applied. A major difference between EGW and its cousin electroslag welding is that the arc in EGW is not extinguished, instead remaining struck throughout the welding process. It is used to make square-groove welds for butt and welding, especially in the shipbuilding industry and in the construction of storage tanks. In EGW, the heat of the welding arc causes the electrode and workpieces to melt and flow into the cavity between the parts being welded. This molten metal solidifies from the bottom up, joining the parts being welded together. The weld area is protected from atmospheric contamination by a separate shielding gas, or by the gas produced by the disintegration of a flux-cored electrode wire. The electrode is guided into the weld area by either a consumable electrode guide tube, like the one used in electroslag welding, or a moving head. When the consumable guide tube is used, the weld pool is composed of molten metal coming from the parts being welded, the electrode, and the guide tube. The moving head variation uses an assembly of an electrode guide tube which travels upwards as the weld is laid, keeping it from melting. Electrogas welding can be applied to most steels, including low and medium carbon steels, low alloy high strength steels, and some stainless steels. Quenched and tempered steels may also be

welded by the process, provided that the proper amount of heat is applied. Welds must be vertical, varying to either side by a maximum of 15 degrees.
Like other arc welding processes, EGW requires that the operator wear a welding helmet and proper attire to prevent exposure to molten metal and the bright welding arc. Compared to other processes, a large amount of molten metal is present during welding, and this poses an additional safety and fire hazard. Since the process is often performed at great heights, the work and equipment must be properly secured, and the operator should wear a safety harness to prevent injury in the event of a fall. EGW uses a constant voltage, direct current welding power supply, and the electrode has positive polarity. A wire feeder is used to supply the electrode, which is selected based on the material being welded. The electrode can be flux-cored to provide the weld with protection from atmospheric contamination, or a shielding gas can be used with a solid wire electrode. The welding head is attached to an apparatus that elevates during the welding process. Also attached to the apparatus are backing shoes which restrain the weld to the width of the workpieces. To prevent them from melting, they are made of copper and are water-cooled. They must be fit tightly against the joint to prevent leaks.
Stud welding is a form of spot welding where a bolt or specially formed nut is welded on to another metal part. The bolts may be automatically fed into the spot welder. Weld nuts generally have a flange with small nubs that melt to form the weld. Studs have a necked down, unthreaded area for the same purpose.

10 Write a brief summary to the text in the previous activity.

11 Say if the following is true or false. Correct the false sentences.

1. Electrogas welding is less hazardous than electroslag welding.
2. Electroslag welding is more frequently used to weld in a horizontal orientation.
3. Carbon Arc Welding is broadly used in industry in the present time.
4. Filler metal is always necessary in Atomic Hydrogen Welding.
5. Quenched and tempered steels are not welded using Electrogas welding.
6. Carbon Arc Welding is the newest arc welding process.

12 Answer the following questions.

1. What kind of electrodes are used in Electrogas and Atomic Hydrogen Welding processes?
2. What structures can be welded by Electrogas welding?
3. Can thick workpieces be easily welded by Electroslag welding?

4. Why is Electrogas welding relatively unsafe and hazardous?
5. What is the difference between Electrogas and Electroslag welding?
6. Why does the operator have to wear protective clothes?

13 Complete the following sentences.

1. To ensure safety while using arc welding processed operators have to wear… .
2. Electroslag welding is no more used to weld… .
3. In Electrogas welding the weld area is protected from atmospheric contamination … .
4. In Atomic Hydrogen Welding the work itself becomes… .
5. Since Electrogas welding is performed at great heigh… .

Writing

14 Write a short report about arc welding. Include the items below.

- Types (SMAW, MMA, GMAW, MIG, FCAW, SAW, GTAW, TIG, electroslag welding, stud arc welding, EGW)
- Types of filler material used (consumable/none-consumable, covered/bare electrode/wire)
- Type of current used (direct/alternating)
- Type of shielding gas used (helium, argon, CO2)
- Major application areas

Speaking

15 Discuss the following questions in the group.

1. What is the difference in methods of gas cutting and gas welding?
2. Is there any difference in equipment used for gas welding and gas cutting?
3. What might be the advantages and disadvantages of gas cutting compared to other methods of cutting metals?
4. Do you remember what appeared before: arc or gas welding?
5. What type of cutting (arc or gas) is :
   a) more expensive
   b) more operator skills demanding
   c) safer
   e) faster

f) more precise?

6. Do you know what metals (steels) are better cut using gas welding?

16 Look at the picture of ***Oxygas Cutting Equipment (Fig. 3)*** *and tell about its design. The phrases below will help you.*

The oxygas cutting equipment consists of …
The main parts of the equipment are …
It also has …
… are installed on (at) …

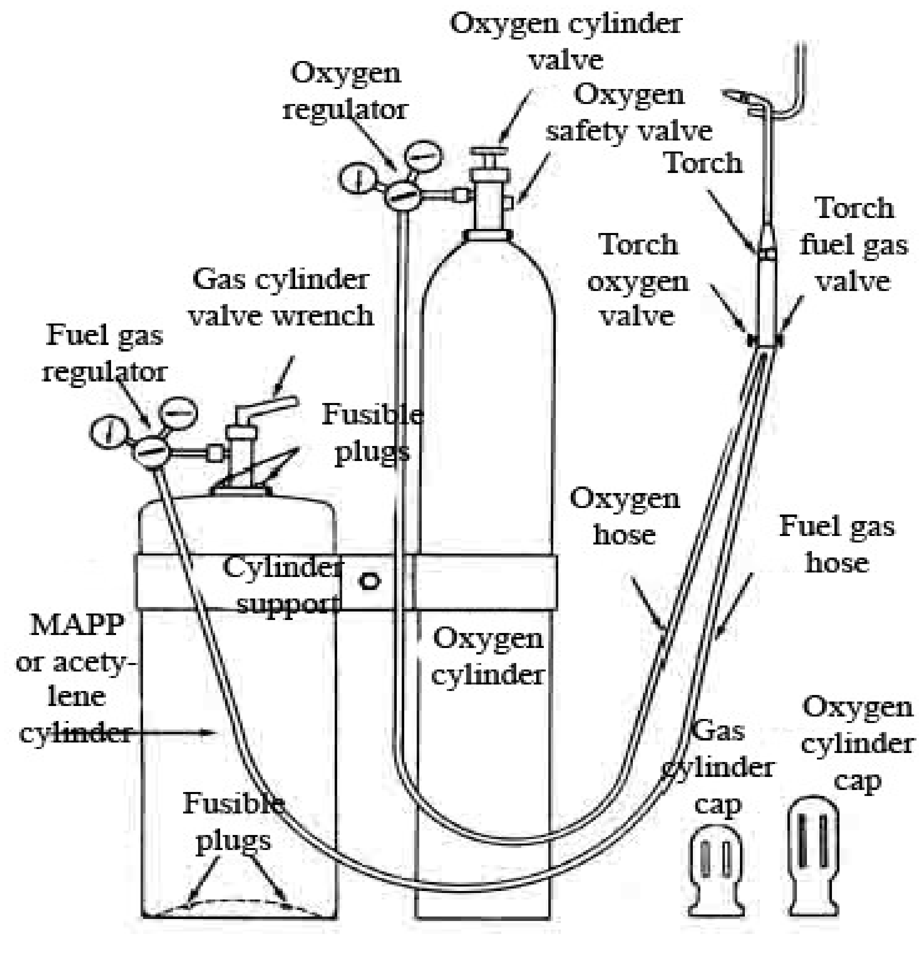


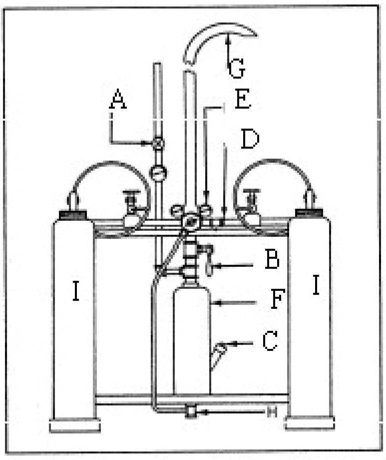
Fig. 2 Oxygas cutting outfit

Reading 3

17 Read about welding gases and fill in the table.

	Acetylene	Mapp Gas
Chemical composition		
Flame temperature		
Colour and odor		
Stability (temperature)		
Cylinder packing		
Dangerous effects on health		

Acetylene



A. Line valve
B. Release valve
C. Filler plug
D. Header pipe
E. Regulator
F. Flash arrestor chamber
G. Escape pipe
H. Check valve and drain plug
I. Acetylene cyllinders

Fig. 3
Portable welding outfit

Acetylene is a flammable fuel gas composed of carbon and hydrogen having the chemical formula C2H2.When burned with oxygen, acetylene produces a hot flame, having a temperature between 5700°F and 6300°F. Acetylene is a colorless gas, having a disagreeable odor that is readily detected even when the gas is highly diluted with air. When a portable welding outfit, similar to the one shown in figure 4 is used, acetylene is obtained directly from the cylinder. In the case of stationary equipment, similar to the acetylene cylinder bank shown in figure at right, the acetylene can be piped to a number of individual cutting stations.

Hazards: Pure acetylene is self-explosive if stored in the free state under a pressure of 29.4 pounds per square inch (psi). A slight shock is likely to cause it to explode. WARNING: Acetylene becomes extremely dangerous if used above 15 pounds pressure.

Cylinder Design

Acetylene can be safely compressed up to 275 psi when dissolved in acetone and stored in specially designed cylinders filled with porous material, such as balsa wood, charcoal, finely shredded asbestos, corn pith, portland cement, or infusorial earth. These porous filler materials aid in the prevention of high-pressure gas pockets forming in the cylinder.

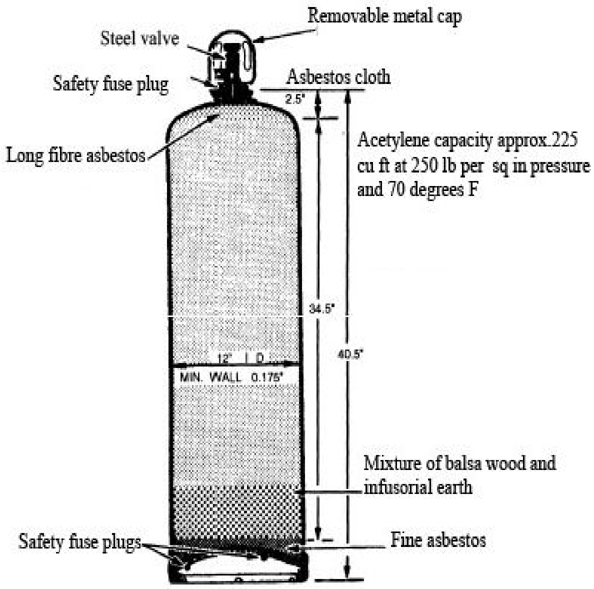


Fig. 4
Acetylene cylinder

Acetone is a liquid chemical that dissolves large portions of acetylene under pressure without changing the nature of the gas. Being a liquid, acetone can be drawn from an acetylene cylinder when it is not upright. You should not store acetylene cylinders on their side, but if they are, you must let the cylinder stand upright for a minimum of 2 hours before using. This allows the acetone to settle to the bottom of the cylinder.

An example of an acetylene cylinder is shown in figure 5. These cylinders are equipped with fusible plugs that relieve excess pressure if the cylinder is exposed to undo heat. A common standard acetylene cylinder contains 225 cubic feet of acetylene and weighs about 250 pounds. The acetylene cylinder is yellow, and all compressed-gas cylinders are color-coded for identification.

MAPP Gas

MAPP (methylacetylene-propadiene) is an all-purpose industrial fuel having the high-flame temperature of acetylene but has the handling characteristics of propane. Being a liquid, MAPP is sold by the pound, rather than by the cubic foot, as with acetylene. One cylinder containing 70 pounds of MAPP gas can accomplish the work of more than six and one-half 225-cubic-foot acetylene cylinders; therefore, 70 pounds of MAPP gas is equal to 1,500 cubic feet of acetylene.

Fig. 5 Compressed gas cylinders containing oxygen oxygen and MAPP gas

Because of its superior heat transfer characteristics, MAPP produces a flame temperature of 5300°F when burned with oxygen. MAPP equals, or exceeds, the performance of acetylene for cutting, heating, and brazing. MAPP is not sensitive to shock and is nonflammable in the absence of oxygen. There is no chance of an explosion if a cylinder is bumped, jarred, or dropped. You can store or transport the cylinders in any position with no danger of forming an explosive gas pocket. The characteristic odor, while harmless, gives warnings of fuel **leak**s in the equipment long before a dangerous condition can occur. MAPP gas is not restricted to a maximum working pressure of 15 psig, as is acetylene. In jobs requiring higher pressures and gas flows, MAPP can be used safely at the full-cylinder pressure of 95 psig at 70 °F. Because of this, MAPP is an excellent gas for underwater work.

Cylinder Design

Total weight for a MAPP cylinder, which has the same physical size as a 225-cubic-foot acetylene cylinder, is 120 pounds (70 pounds which is MAPP gas). MAPP cylinders contain only liquid fuel. There is no cylinder packing or acetone to impair fuel withdrawal; therefore, the entire contents of a MAPP cylinder can be used. For heavy-use situations, a MAPP cylinder delivers more than twice as much gas as an acetylene cylinder for the same time period.

Speaking

18 Discuss in the group advantages and disadvantages of using Acetylene and map gas. Say which gas you would prefer to use for gas welding and why.

Reading 4

19 Skim the two texts ***Regulators*** *and* ***Cutting Torches*** *and write annotations.*

Regulators

You must be able to reduce the high-pressure gas in a cylinder to a working pressure before you can use it. This pressure reduction is done by a regulator or reducing valve. The one basic job of all regulators is to take the high-pressure gas from the cylinder and reduce it to a level that can be safely used. Not only do they control the pressure but they also control the flow (volume of gas per hour).

Regulators come in all sizes and types. Some are designed for high-pressure oxygen cylinders (2,200 psig), while others are designed for low-pressure gases, such as natural gas (5 psig). Some gases like nitrous oxide or carbon dioxide freeze when their pressure is reduced so they require electrically heated regulators.

Most regulators have two gauges: one indicates the cylinder pressure when the valve is opened and the other indicates the pressure of the gas coming out of the regulator. You must open the regulator before you get a reading on the second gauge. This is the delivery pressure of the gas, and you must set the pressure that you need for your particular job.

The pressures that you read on regulator gauges is called gauge pressure. If you are using pounds per square inch, it should be written as psig (this acronym means pounds per square inch gauge). When the gauge on a cylinder reads zero, this does not mean that the cylinder is empty. In actuality, the cylinder is still full of gas, but the pressure is equal to the surrounding atmospheric pressure. Remember: no gas cylinder is empty unless it has been pumped out by a vacuum pump.

Problems And Safety

Regulators are precise and complicated pieces of equipment. Carelessness can do more to ruin a regulator than any other gas-using equipment. One can easily damage a regulator by simply forgetting to wipe clean the cylinder, regulator, or hose connections. When you open a high-pressure cylinder, the gas can rush into the regulator at the speed of sound. If there is any dirt present in the connections, it will be blasted into the precision-fitted valve seats, causing them to leak. This results in a condition that is known as creep. Creep occurs when you shut of the regulator but not the cylinder and gas pressure is still being delivered to the low-pressure side.

Regulators are built with a minimum of two relief devices that protect you and the equipment in the case of regulator creep or high-pressure gas being released into the regulator all at once. All regulator gauges have blowout backs that release the pressure from the back of the gauge before the gauge glass explodes. Nowadays, most manufacturers use shatterproof plastic instead of glass. The regulator body is also protected by safety devices.

Blowout disks or spring-loaded relief valves are the two most common types of devices used. When a blowout disk ruptures, it sounds like a cannon. Spring-loaded relief valves usually make howling or shrieking like noises. In either case, your first action, after you recover from your initial fright, should be to turn off the cylinder valve. Remove the regulator and tag it for repair or disposal. When opening a gas cylinder, you should just "crack" the valve a little. This should be done before attaching the regulator and every time thereafter. By opening the cylinder before connecting the regulator, you blow out any dirt or other foreign material that might be in the cylinder nozzle. Also, there is the possibility of a regulator exploding if the cylinder valve is opened rapidly.

WARNING: Oil or other petroleum products must never be used around oxygen regulators because these products will either cause a regulator explosion or fire

Cutting Torches

The equipment and accessories for oxygas cutting are the same as for oxygas welding except that you use a cutting torch or a cutting attachment instead of a welding torch. The main difference between the cutting torch and the welding torch is that the cutting torch has an additional tube for high-pressure cutting oxygen. The flow of high-pressure oxygen is controlled from a valve on the handle of the cutting torch. In the standard cutting torch, the valve may be in the form of a trigger assembly like the one in figure below. On most torches, the cutting oxygen mechanism is designed so the cutting oxygen can be turned on gradually. The gradual opening of the cutting oxygen valve is *particularly helpful in operations, such as hole piercing and rivet cutting.*

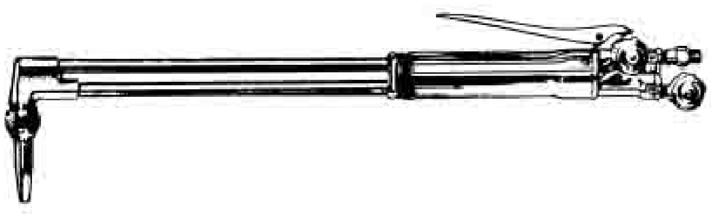


Fig. 6 One piece oxygas cutting torch

Torch Body

Most welding torches are designed so the body of the torch can accept either welding tips or a cutting attachment. This type of torch is called a combination torch. The advantage of this type of torch is the ease in changing from the welding mode to the cutting mode. There is no need to disconnect the hoses; you just unscrew the welding tip and then screw on the cutting attachment. The high-pressure cutting oxygen is controlled by a lever on the torch handle, as shown in figure below.

Cutting Torch Tips

As in welding, you must use the proper size cutting tip if quality work is to be done. The preheat flames must furnish just the right amount of heat, and the oxygen jet orifice must deliver the correct amount of oxygen at just the right pressure and velocity to produce a clean cut. All of this must be done with a minimum consumption of oxygen and fuel gases. Careless workers and workers not acquainted with the correct procedures waste both oxygen and fuel gas.

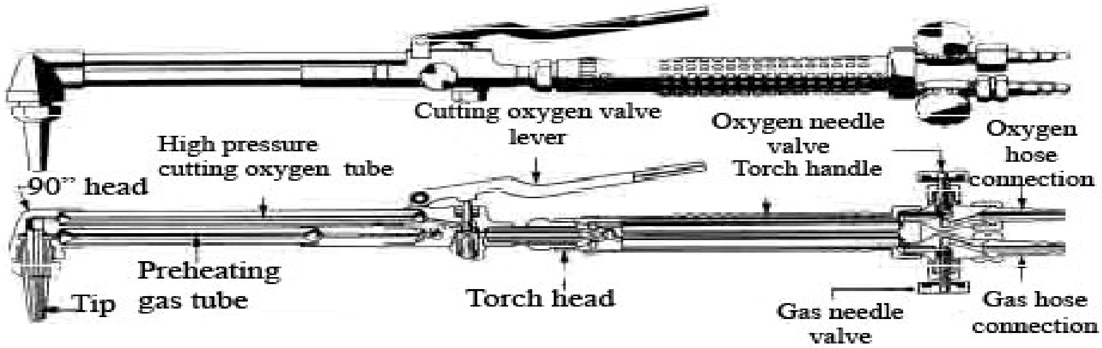


Fig. 7 Combination torch

Each manufacturer makes many different types of cutting tips. Although the orifice arrangements and the tips are much the same among the manufacturers, the part of the tip that fits into the torch head often differs in design.

Because of these differences, there is the possibility of having two or three different types of cutting torches in your kits. Make sure that the cutting tips match the cutting attachment and ensure that the cutting attachment matches the torch body. Figure above shows the different styles of tips, their orifice arrangements and their uses. The tips and sears are designed to produce an even flow of gas and to keep themselves as cool as possible. The seats must produce leakproof joints. If the joints leak, the preheat gases could mix with the cutting oxygen or escape to the atmosphere, resulting in poor cuts or the possibility of flashbacks.

To make clean and economical cuts, you must keep the tip orifices and passages clean and free of burrs and slag. If the tips become dirty or misshapened, they should be put aside for restoration.

Vocabulary

rig	какое-л. приспособление, устройство, механизм Syn: apparatus , device
hose	шланг
spark	искра

igniter	воспламенитель
wrench	гаечный ключ
outfit	агрегат, оборудование, принадлежности, набор (приборов, инструментов)
pressure gauge	манометр
leak	течь, протечка, утечка
orifice	отверстие
single-stage (regulator)	однокамерный
flashback	обратный удар пламени (проникающий в шланг сварочной горелки)

20 Read the texts above more carefully and complete the sentences.

1. The most common devices for pressure reduction are … and …
2. Regulators control pressure and …
3. Regulators have two gauges: one is for indicating the cylinder pressure and the other is for indicating …
4. Psig is an acronym from …
5. Psig is used to measure …
6. Valve leaks in regulators can be caused by …
7. A combination torch is a torch which can accept either welding tips or …
8. It is necessary to keep the tip orifices and passages clean and free of …

21 Look at the pictures of torches on pages 67-68 and tell about their design.

Reading 5

*22 Read the detailed instruction for **Setting up the equipment** for oxygas welding and continue filling in the table below.*

Instructions (What should be done)	**Precautions (What shouldn't be done)**
When using fuel and oxygen tanks they should be fastened securely to a wall, a post or a portable cart in an upright position.	An oxygen tank should never be moved around without the valve cap screwed in place.

Setting up the equipment

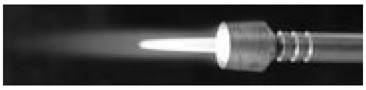


Fig. 8
Oxygen Rich Butane Blow Torch Flame

When using fuel and oxygen tanks they should be fastened securely to a wall, a post or a portable cart in an upright position. An oxygen tank is especially dangerous for the reason that the oxygen is at a pressure of 21 MPa (3000 lbf/in^2 = 200 atmospheres) when full and if the tank falls over and the valve strikes something and is knocked off, the tank will become an unguided and unpredictable missile powered by the compressed oxygen. It is for this reason that an oxygen tank should never be moved around without the valve cap screwed in place.

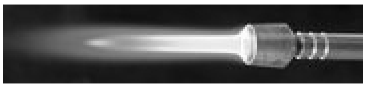


Fig. 9
Fuel Rich Butane Blow Torch Flame

Never lay the acetylene tank down while being used, as the acetone would start to come out through the valve. If it was laid down while being transported, it must be set upright, valve on top.

After the oxygen tank is securely fastened, remove the valve cap. With the valve opening pointed away from the welder, open the valve slightly for just a moment and then close it. This serves two purposes. For one, it blows out any dirt or dust that may have settled in the valve. This dirt would otherwise end up in the regulator and shorten its life and accuracy. For another, when a tank is filled, the worker has a tendency to tighten the valve securely to make certain it is closed completely. It is better to break it loose now than when the regulator is in place. Attach the oxygen regulator and tighten the nut. Never use pliers, as the pliers will soon damage the brass nut; always use a wrench. Also, there is a tendency of welders to over tighten the nut. If it is not leaking, then it is tight enough. If a great amount of torque is needed to stop it leaking, or if it will not stop leaking in spite of any amount of tightening, then there is something wrong with the nut, the gasket or the valve.

Attach the fuel regulator to the fuel tank in the same manner. The nut on the fuel regulator usually has left hand threads.

Attach the flexible hoses from the regulators to the torch. The oxygen hose is usually colored green and the fuel hose red. The fuel hose has left hand threaded connectors at both ends and the oxygen has right hand threaded connectors.

With the valves on the torch closed, and the knobs on the regulators screwed out until loose (0 setting), open the valves on the fuel and oxygen tanks. Open the oxygen valve slightly and then wait while the high pressure gauge on the regulator stops rising. Then open the valve fully, until it stops turning. This is a back stop valve. Turning the valve all of the way out prevents leakage through the packing of the valve.

Open the fuel valve also. Only open an acetylene valve one quarter turn. This helps prevent the acetylene from being drawn off too quickly. If acetylene 'bubbles' too rapidly from the acetone, it might become unstable. Open the valve on a LPG tank out completely as on an oxygen tank and for the same reasons.

If there are any leaks in the connections, regulators or torch, or any other faults with the equipment, a safety hazard exists. The equipment should not be used.

Never oil an oxygen regulator. It will cause a fire or explosion — solid brass regulators can be blown apart from the force. Keep oxygen away from all combustibles.

After this preparation, set the regulators at the desired pressure. For acetylene, this should never be more than 103 kPa (15 lbf/in^2). To prevent a large yellow, sooty flame when first lighting the torch, open both the fuel and the oxygen valves (more fuel than oxygen), and light a flame with a 'striker' or by some other means. After the flame is adjusted to the proper size, open the oxygen valve and adjust it to give the desired balance of fuel and oxygen. Usually a neutral flame is used: this is a flame where the fuel and oxygen supplied to the torch tip are both completely combined with each other. An oxidizing flame has an excess of oxygen and a reducing flame has an excess of fuel (carbon). An oxidising flame is used for cutting and a reducing flame is used for annealing e.g. to soften steel sheet metal.

An acetylene flame (as is characteristic of most fuel/oxygen flames) has two parts; the light blue to white colored inner cone and the blue colored outer cone. The inner cone is where the acetylene and the oxygen combine. The tip of this inner cone is the hottest part of the flame. The outer cone is where hydrogen and carbon monoxide from the breakdown of the acetylene and partial combustion of the inner cone combine with the oxygen in the surrounding air and burns.

A neutral flame has a well defined inner cone. A reducing flame has a feathery inner cone. An oxidizing flame has a smaller inner cone that is sharply defined and is pale blue. The welder observes this while adjusting the fuel and oxygen valves on the torch to get the correct balance for the job at hand. There is also a difference in the noise the flame makes. Adjusting the flame is not a hard thing to do after a little experience and practice.

The size of the flame can be adjusted to a limited extent by the valves on the torch and by the regulator settings, but in the main it depends on the size of the orifice in the tip. In fact, the tip should be chosen first according to the job at hand, and then the regulators set accordingly.

Speaking

23 Imagine you are explaining to an apprentice how to set up the equipment. Use the right column of the table in the previous exercise and the tips below to give the instructions.

First fasten fuel and oxygen tanks securely to a wall, a post or a portable cart in an upright position.
Then remove … .
After that … .
…
…
Having attached ... .
…
…
…
…
After this preparation ... .
…
Finally … .

Revision

24 Decode the abbreviations.

SMAW, MMA, GMAW, MIG, FCAW, SAW, GTAW, TIG, EGW

25 Label the picture of a portable welding outfit with the words below.

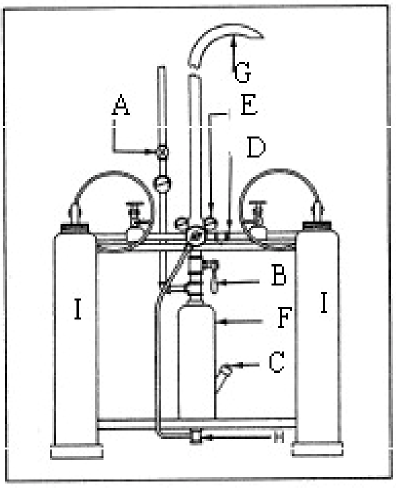


Fig. 10 Portable welding outfit

header pipe
line valve
filler plug
release
regulator
escape pipe
flash arrestor chamber
check valve and drain plug
acetylene cylinder

PART 5. MODERN DEVELOPMENTS

Lead-in

1 In small groups discuss the trends of modern research in welding listed below. Decide which of them are of primary importance. Think of some other trends. Report to the class.

- new welding methods
- automation of welding
- computer control
- energy saving technologies
- environmentally friendly technologies
- safety improvements

Reading 1

2 You will read the text ***Friction Stir Welding (FSW).*** *Before you read discuss the following questions in the group.*

1. Is the method of friction stir welding a conventional one?
2. What makes it conventional/unconventional?
3. What material does it best fit for?

3 Skim the text and make its brief summary.

Friction Stir Welding (FSW)

H.H. Bhadeshia

Friction stir welding, a process invented at TWI, Cambridge in 1991, involves the joining of metals without fusion or filler materials. It is used already in routine, as well as critical applications, for the joining of structural components made of aluminium and its alloys. Indeed, it has been convincingly demonstrated that the process results in strong and ductile joints, sometimes in systems which have proved difficult using conventional welding techniques. The process is most suitable for components which are flat and long (plates and sheets) but can be adapted for pipes, hollow sections and positional welding. The welds are created by the combined action of frictional heating and mechanical deformation due to a rotating tool. The maximum temperature reached is of the order of 0.8 of the melting temperature.

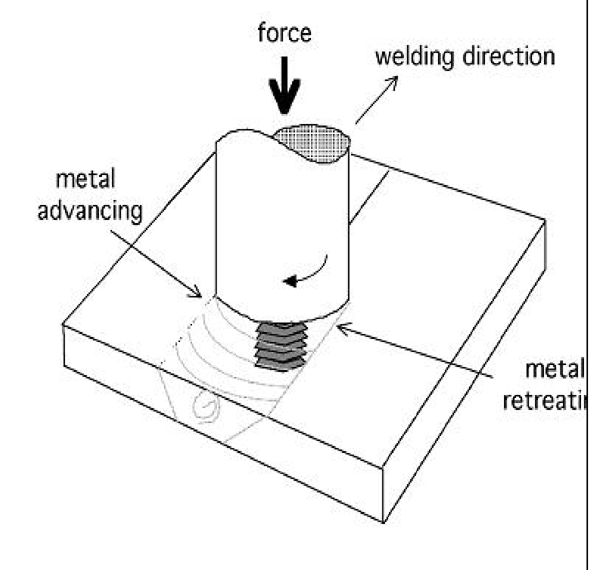


Fig. 11 Tool in operation

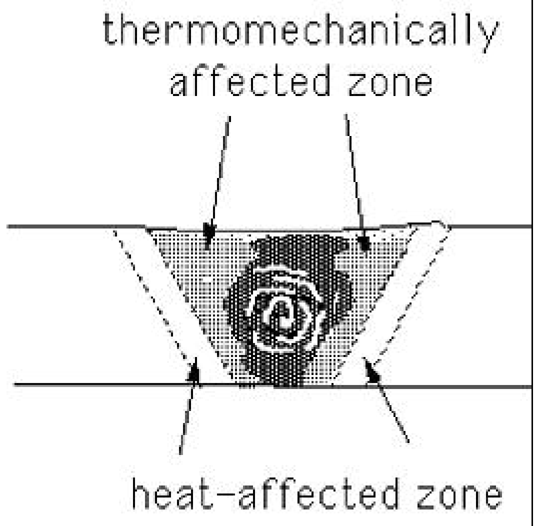


Fig. 12 HAZ

The tool has a circular section except at the end where there is a **threaded** probe or more complicated flute; the junction between the cylindrical portion and the probe is known as the **shoulder**. The probe penetrates the work piece whereas the shoulder rubs with the top surface. The heat is generated primarily by friction between a rotating-translating tool, the shoulder of which rubs against the work piece. There is a volumetric contribution to heat generation from the adiabatic heating due to deformation near the pin. The welding parameters have to be adjusted so that the ratio of frictional to **volumetric** deformation--induced heating decreases as the work piece becomes thicker. This is in order to ensure a sufficient heat input per unit length.

The microstructure of a friction-stir weld depends in detail on the tool design, the rotation and translation speeds, the applied pressure and the characteristics of the material being joined. There are a number of zones. The heat-affected zone (HAZ) is as in conventional welds. The central nugget region containing the onion-ring flow-pattern is the most severely deformed region, although it frequently seems to dynamically recrystallise, so that the detailed microstructure may consist of **equiaxed** grains. The layered (onion-ring) structure is a consequence of the way in which a threaded tool deposits material from the front to the back of the weld. It seems that cylindrical sheets of material are extruded during each rotation of the tool, which on a weld cross-section give the characteristic onion-rings.

The thermomechanically-affected zone lies between the HAZ and nugget; the grains of the original microstructure are retained in this region, but in a deformed state. The top surface of the weld has a different microstructure, a consequence of the shearing induced by the rotating tool-shoulder.

The Machine

Fig. 13 Friction-stir welding machine

This is a picture of a friction stir welding (FSW shows a typical) machine. This one is at the Joining and Welding Research Institute (JWRI) of Osaka University, Japan.

The Tool

Below you can see an illustration of some types of tools. Each tool has a shoulder whose rotation against the substrate generates most of the heat required for welding. The **pin** on the tool is plunged into the substrate and helps stir the metal in the solid state.

Fig. 14 The tools

The Fixture and Weld

The two halves to be joined must be rigidly fixed before the welding operation (first picture below). The pin, which is an integral part of the tool, is plunged into the metal to help stir it up; the shoulder of the tool generates much of the heat. As the weld is completed, the tool is withdrawn leaving behind a hole. The weld is designed so that such regions can be discarded from the component. The presence of a hole may not be appropriate when welding pipes or storage vessels. The hole can be avoided by designing the tool such that only the pin can be retracted automatically and gently into the shoulder, leaving behind an integral weld.

Fig. 15 The fixture

FSW of Steel

Steel can be friction stir welded but the essential problem is that tool materials wear rapidly. Indeed, the wear **debris** from the tool can frequently be found inside the weld. The process would therefore be used in special circumstances where other welding methods are inadequate. These circumstances have yet to be clarified. There are so many good methods by which steel can be welded. The example below is the FSW of 316L stainless steel. Notice that the sample becomes red-hot during welding.

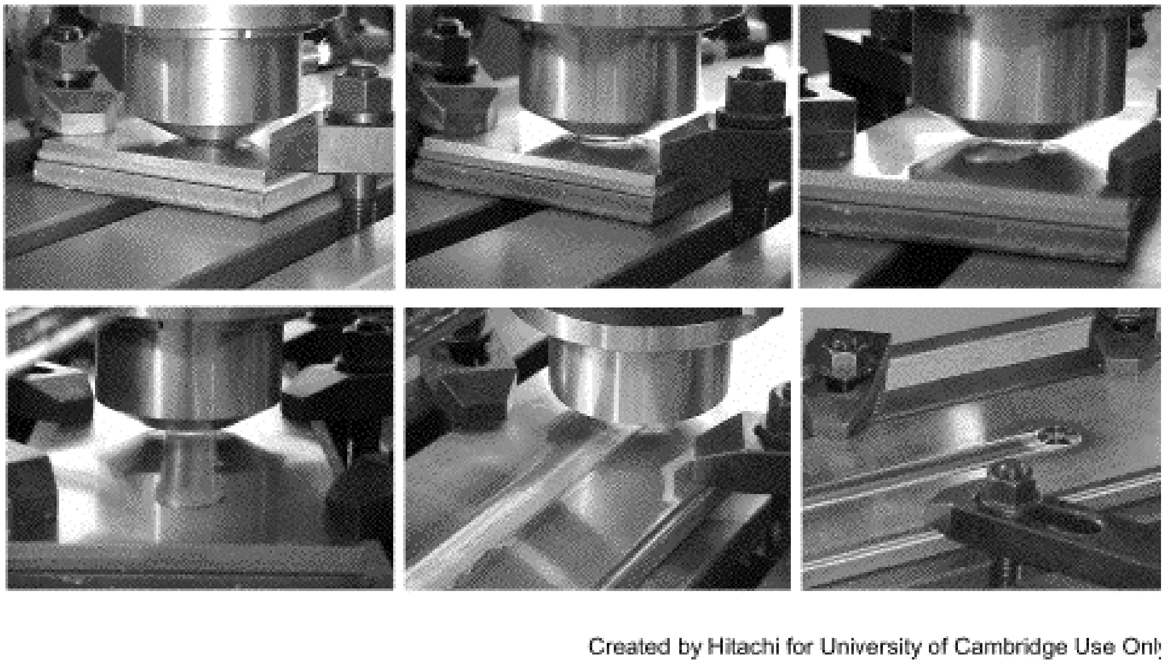


Fig 16 Obtaining a weld

Since the tool gets red hot, it is necessary to protect it against the environment using a shielding gas. A possible use of FSW in the welding of steels is in the context of stainless steels. Austenitic stainless steels can easily be welded using conventional arc welding and other processes. However, FSW can offer lower distortion, lower shrinkage and porosity. More important is the avoidance of fumes containing hexavalent chromium which is carcinogenic. In addition, chemical segregation effects associated with welding processes involving solidification are avoided. Such segregation can lead to a degradation of corrosion resistance since electrochemical cells are set up between **solute**-rich and poor domains.

Friction Stir Welding of Cast Aluminium Alloy

The most popular aluminium casting-alloy contains about 8 wt% of silicon. It therefore solidifies to primary aluminium-rich dendrites and a eutectic mixture of aluminium solid-solution and almost pure silicon. The latter occurs as coarse silicon particles which tend to be brittle. The cast alloy usually has some porosity. Friction stir welding has the advantage that it breaks up the coarse silicon particles and heals any pores by the mechanical processing, as illustrated below.

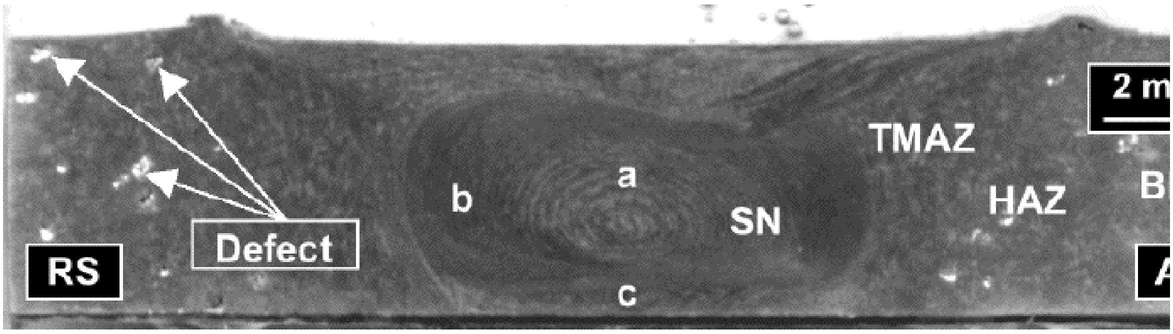
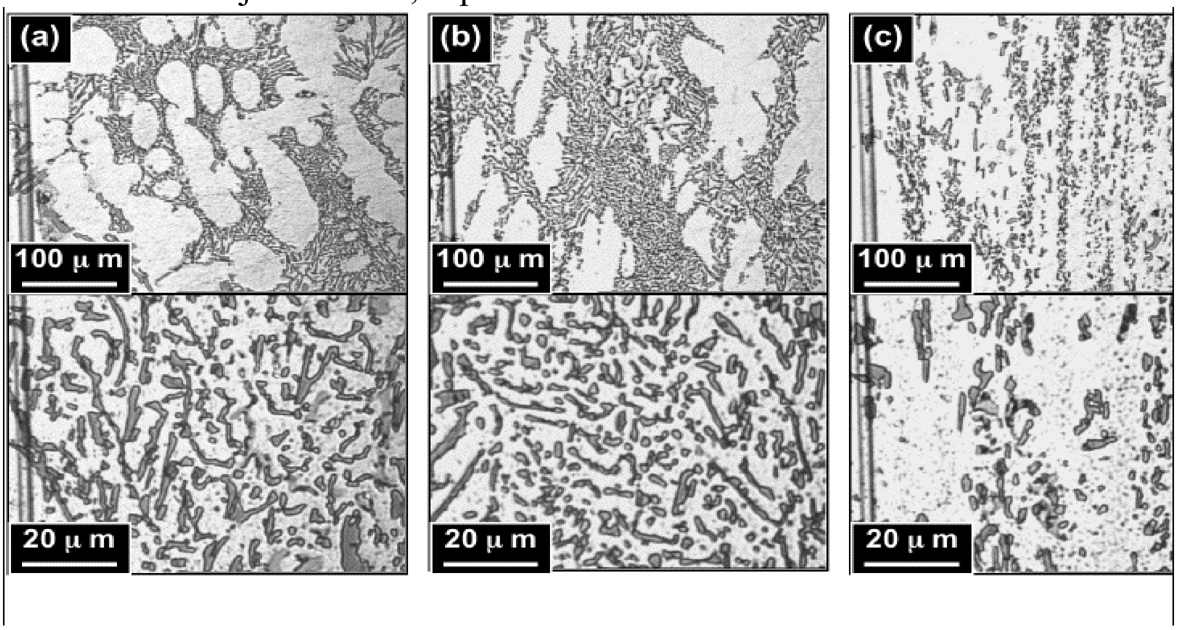


Fig. 17 A section through a friction stir weld made in an Al-Si casting alloy.

There are pores indicated in the base metal (BM). HAZ represents the heat affected zone, TMAZ – the thermomechanically affected zone, and SN – the stir nugget. The photographs in this section have kindly been provided by Professor H. Fujii of JWRI, Japan.



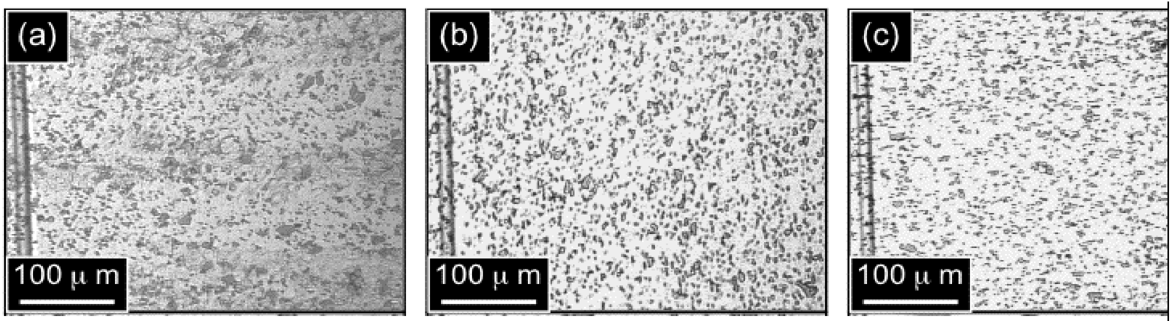


Fig. 18 Optical micrographs of regions (a), (b) and (c) of the stir nugget.

The location of these regions is identified in macroscopic section presented above.Optical micrographs showing the microstructure in (a) the base metal; (b) heat-affected zone; (c) the thermo mechanically affected zone, where considerable refinement of the silicon has occurred.

Tensile strength (MPa)	Proof stress (MPa)	Elongation (%)	Fracture local
Joint 150	85	1.6	BM
Weld 179	87	5.3	TMAZ
SN 251	96	14.4	SN

The refinement of silicon and elimination of porosity leads to better mechanical properties in the weld than in the base plates.

Vocabulary

ductile	гибкий, ковкий, поддающийся обработке
threaded	с резьбой, нарезной
pin	цапфа
shoulder	буртик, поясок
debris	осколки, обломки, обрезки, лом
volumetric	объемный
shrinkage	усадочная деформация
solute	растворенное вещество, раствор
equiaxed	равноосный

4 Read the Russian text below and correlate it with the text ***Friction Stir Welding (FSW)*** *in the previous activity. Say if it is a good abstract for the English text. Why? Why not?*

Friction Stir Welding (FSW)
Сварка трением

H.H. Bhadeshia
Х.Х. Бхадешия

Метод сварки трением, разработанный транснациональной корпорацией TWI (Кембридж, Великобритания) в 1991 г., заключается в получении соединения металлов без использования плавления и присадочных материалов. Данный метод получил широкое применение для сварки металлических листов, однако он также может применяться для сварки труб, полых секций и др. Сварной шов образуется благодаря сочетанию фрикционного разогрева и механической деформации, вызываемых вращающимся органом – цапфой. Максимально достижимая температура составляет порядка 0,8 от температуры плавления.

Рабочий орган имеет круглое сечение, на конце которого расположен зонд с насечкой. Стык цилиндрической части с зондом называют буртиком. Зонд проникает в свариваемые поверхности, в то время как буртик производит трение по поверхности. Тепло вырабатывается главным образом в результате трения рабочего органа о поверхность свариваемых листов металла.

По завершении шва рабочий орган отводят, на месте его работы остается отверстие. Поскольку образующееся отверстие недопустимо при сварке труб, его образования можно избежать применением специальной конструкции рабочего органа, в котором цапфа автоматически плавно втягивается в буртик, оставляя после себя неповрежденный шов.

5 Read the text carefully and answer the following questions.

1. What is Friction Stir Welding method based on?
2. How is the weld formed?
3. What do the welding parameters depend on?
4. What, in your opinion, are the most important advantages/disadvantages of the Friction Stir Welding method?
5. Want is the best sphere of application of this method at present?

6 Say if the following is true or false. Correct the false sentences.

1. FSW is not used to weld steels.
2. It’s impossible to avoid holes in welds made by FSW method.

3. The maximum temperature reached during FSW is above the melting temperature.
4. The characteristics of the material being joined affect the microstructure of a friction-stir weld.
5. FSW is the only method for welding austenitic stainless steels.
6. Pipes can be welded using FSW.

Reading and speaking

7 In small groups read the characteristics of FSW given below and distribute them into two categories in the table. Compare with other groups. Then speak about advantages and disadvantages of FSW.

Advantages	Disadvantages

- The method requires a stable welding machine with a powerful fixture.
- Material from 15-30 mm can be welded on both sides.
- No joint preparation, only **degreasing**.
- The method can only be used on straight, flat workpieces or hollow profiles with an **abutment** or **backing**.
- High, consistent quality.
- No grinding or brushing.
- No consumables.
- No shielding gas.
- This welding method leaves an end hole when the tool is pulled away from workpiece. In many cases, this hole can be cut off, but, in other cases, it has to be sealed using another method.
- Flat surface without weld **reinforcement** or splatter.
- No **magnetic blowing** as the welding is done without an arc.
- Environmentally-compatible method without flash, fumes or ozone formation. Less risk of pores and cracking as the temperature never reaches the melting point of aluminium.
- No burning off of alloy substance as the temperature never reaches melting point.
- Alloys which are difficult to weld can be welded as there is only a small risk of hot cracking. High productivity.
- Material thickness from 1.6-15 mm can be welded as single-pass procedures.

- The back of the object must be accessible if 100% penetration is necessary.
- The welding equipment should preferably be stationary.

Vocabulary

abutment	торец; упор; опора,
backing	опора
degreasing	обезжиривание
magnetic blowing	магнитное срывание дуги

8 Use the words and phrases from the list below to fill in the blanks in the sentences.

Rotating bodies, manual welding, sponsorship project, necessary expertise, in collaboration with, frictional heat, without any negative observations, build up data bank, sufficiently high temperature, environmentally-compatible.

1. … is being replaced by automatic and semi-automatic types of welding in many applications.
2. They could buy the new equipment only thanks to a successfully realized … .
3. … are necessary elements of friction stir welding.
4. The new project was realized … foreign partners.
5. In order for the weld to be formed … in the welding area should be provided.
6. After the thorough repairs the equipment had been running for 2 years … .
7. The quality control supervisors had to carry out … before putting the welding machine into operation.
8. The experience the engineers had in welding such structures helped them … necessary for further development of the product.
9. … resulting from rotating bodies coming into direct contact can be removed by special coolers.
10. This new welding machine is both operator friendly and … .

Writing

9 Write a short report about FSW according to the following plan:

1. The principle of FSW.
2. Working environment.
3. Advantages and disadvantages.
4. Applications.

Reading 2

10 You will read the text **Man-machine Communication for Multi-run Arc Welding.** *Before you read discuss the following questions in the group.*

1. What is an automated welding system?
2. What might be the advantages of automated welding systems compared with manual welding?
3. What part do you think can never be welded using automated welding?

11 Read the text and answer questions.

1. What are the functions of the described automated system?
2. In what cases must the welding process be automatically stopped?
3. What does the system do when the weld is completed?
4. What do the pre-programming modules include?
5. What parameters are displayed on the screen during the welding process?
6. What can an operator do when he receives a warning from the automated system?
7. What does the remote control unit contain?
8. Where are all the important events happening during the welding process stored?
9. What is registered in the log file?

Man-machine Communication for Multi-run Arc Welding

The multi-run welding of heavy components imposes special demands on **man-machine communication** (MMC) for automated welding systems. **Welding sequences** of several hours with limited operator surveillance necessitate pre-programming, not only of the nominal process data, but also of other conditions for the successful performance of the welding process in varying external conditions. Warnings of conditions requiring the operator's attention must be given during welding. Should a situation occur in which the quality of the weld is jeopardized, the process must be stopped in a controlled manner and the reason for the stop must be displayed. Upon completion of the weld, a presentation, indicating all the important events during the welding cycle, should be made to determine the amount of **non-destructive testing**. Provision should be made for further detailed investigations of optional parts of the cycle, as well as for the storage and documentation of the course of the process.

The operator interface for the ESAB multi-run MMC is an industrial PC. The pre-programming modules are divided into blocks of set-up parameters, process parameters, warnings, reports and stop limits. Different sets of process parameters can be automatically retrieved during the welding sequence. During welding, the screen shows the preprogrammed parameters, the actual measured values and the way the process is progressing (e.g. layer, bead and position).

If a warning is activated, the operator is given the choice of immediately stopping the process, stopping it after the completion of the bead or allowing it to continue.

A small remote control box, which can be hand-held, contains the controls the operator needs for preparing, starting and stopping the process. The control system registers the welding sequence in two separate files, the Weld Report and the multi-run. In the Weld Report, all the installation parameters such as wire type and wire dimension, flux (or gas) type and permissible inter-pass temperatures are stored, together with the specified process parameters such as welding voltage, welding current and welding speeds and their report, alarm and stop link.

All the important events during welding, such as start, stop(s), restarts, exceeded report limits and warnings for flux level, high or low interpass temperature, are stored in the Weld Report. All the events are stored together with the actual date, time, weld layer, **weld bead** and position in the joint. Should the event be an exceeded process parameter, the parameters at the time in question are also stored.

In the Log File, the position and process parameters are continuously registered (every 20 mm). A normal Log File report for a thick-walled welding object could fill 1,000 pages.

The Weld Report provides a good overview of important events during welding. The reported events provide valuable information for the planning of non-destructive testing and offer easily-accessible documentation of the welding process. If further investigations are deemed necessary, the Weld Report constitutes a good register for entering the Log Files in which detailed information from the sectors associated with the reported events can be found.

The multi-run control system can also be connected to customers' central computer systems for documentation or further processing of both Weld Reports and Log Files, together with other quality control data.

Vocabulary

run	проход
man-machine communication	интерфейс человек-машина
welding sequence	последовательность сварки, порядок наложения швов
non-destructive testing	испытания без разрушения образца, неразрушающий контроль
interpass temperature	температура начала мартенситных превращений
weld bead	наплавленный валик сварного шва
log file	системный журнал

Speaking

12 Specify the functions of:

- *Remote control box*
- *Weld Report*
- *Log File*

13 Use the verbs from the left column and the phrases from the right column to speak about advantages of automated welding systems.

1 to provide 2 to allow 3 to enable the operator 4 to result in 5 to offer	a) good overview of important events during welding b) valuable information for the planning of non-destructive testing c) easily-accessible documentation of the welding process d) to choose to stop the process immediately, stop it after the completion of the bead or allow it to continue **e) better weld quality**

14 Translate the following sentences into English:

1. Использование автоматизированных сварочных систем позволяет легко определить объем необходимого контроля качества.
2. В случае возникновения угрозы качеству сварного шва сварочный процесс немедленно прекращается.
3. Оператор может контролировать подготовку, начало и завершение сварочных операций с помощью пульта дистанционного управления.
4. Данные о дате, времени выполнения операции сварки, сварном слое, наплавленном валике сварного шва сохраняются в отдельном файле.
5. Автоматизированные сварочные системы не требуют значительного вмешательства оператора в ход сварочного процесса.
6. Информация о типе и диаметре сварочной проволоки заносится в программу.
7. По окончании сварки на дисплее отображается вся наиболее важная информация о ходе процесса сварки.
8. Записанные параметры представляют собой ценную информацию о процессе сварки.
9 Данные поступают в центральную вычислительную систему для дальнейшей обработки.
10. Автоматизированная сварочная система обеспечивает успешное осуществление сварочного процесса.

Reading 3

15 Make an abstract of the article ***IT in Welding and Cutting for the Welding Engineer –PC Programs and the Internet***

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IT in Welding and Cutting for the Welding Engineer – PC Programs and the Internet

The PC has now become an essential tool in the work of the engineer for not only **word processing** but also specialized tasks such as in design, **simulation** and performance assessment. Within the manufacturing industry sector, most engineers have access to a PC and the vast majority can be classed as frequent users. It is not surprising, therefore, that in response to the growing market demand, a wide range of computer programs have been written specifically for the welding engineer. Whilst PC programs can be considered to be a mature source of welding engineering IT, over the last year the Internet has emerged as a new exciting source of welding related information.

As the Internet is already widely used by many welding engineers as a source of IT, guidelines are provided on how the vast amount of information on welding engineering related topics can be accessed.

Welding engineering software for the PC

The first IT packages written for the welding engineer were for carrying out simple calculations such as the preheat temperature level to avoid hydrogen cracking. However, as the PC became more powerful (faster computing speeds and additional memory), their use was extended to mass storage of information in databases such as for welding procedures and welder qualification. More recently, software has incorporated novel programming techniques, expert systems for knowledge based advisory type software and multimedia systems for advisory and education and training software. The main advantage of expert systems is that they are capable of encapsulating expert knowledge, which may be largely subjective. Thus, operation of an expert system differs from that of a conventional software which progresses in a predetermined, step by step manner until a result is obtained e.g. the preheat temperature or the output of a database.

Interrogation of a problem solving expert system will produce an output, which is usually advice or an opinion as to the likely cause of the problem and the recommendations to avoid the problem in the future.

A noteworthy advance in computer hardware in recent years has been the inclusion of a CD ROM player in the PC to provide a multimedia capability. Multimedia combines scanned photographs, graphics, animation, audio and video action with very fast processing and large databases to provide very visual / interactive software.

T he CD ROM disk is crucial in that with a capacity of 700MB can store over 250,000 pages of text, or up to 30 mins of video, equivalent to 450 high density 3.5 in floppy disks.

Commercially available software for the welding engineer

There is now a wide range of powerful software available to the welding engineer which makes best use of the computing, memory, knowledge based and/or *multimedia facilities* of the PC. The IT programs produced as aids for the welding engineer can be conveniently grouped into the following categories:

- Repetitive calculations;
- Storage of Information;
- Interpretation of Standards;
- Advisory;
- Simulation;

- Education and Training.

Many companies have written software for *in-house use* but the examples described here have been restricted to commercially available software.

Repetitive Calculations

This group was the first type of software written specifically to help the welding engineer carry out routine or time consuming calculations. Topics include the calculation of *weld volume*, **consumable** requirements, cost of fabrication and design calculations for **fatigue service**. WELDVOL is typical in that it will allow the user to calculate the volume of weld metal to be deposited and from this information, the number of **rods**, or **reels of wire**, to be purchased. The program can accommodate a range of arc processes, joint types and **parent metals**.

Storage of Information

XWELD is a welding procedure management system. The system is a *multi-user* relational database and has the following advantages over a paper based document control system:

- Integrated drawing system and graphics library;
- Electronic distribution of procedures;
- Search functionality for all essential variables of the procedure;

QMWELD is a **complementary** program for management of fabrication information for ensuring that a fabrication is completed on time and to an appropriate standard. The system gives full **traceability** with **NDT records**.

Interpretation of Standards

FATIGUEWISE is based on BSI 7910 (formally PD 6493), "Guidance on Methods for Assessing the Acceptability of Flaws in Fusion Welded Structures". The software allows analysis of structures, for safety critical applications, using either the fracture procedures or the general fatigue procedures.

FATIGUEWISE is a typical software for interpreting a standard which is a complex text procedure. A set of rules derived from the standard are **embedded** in the software ensuring that each time an assessment is made the standard is applied equally rigorously. As most **assessments** require numerous calculations, the software will save the user both time and costs especially when carrying out a *sensitivity* or *critical* analysis by varying one of the *input parameters*.

The use of a *friendly graphical interface* ensures that the user is only asked for information specific to the current assessment.

Advisory

STAYING IN SHAPE is an expert/multimedia system that provides *practical advice* and training on how to **overcome** the problem of **distortion** caused by welding and cutting operations. The information is based on expert knowledge and practical experience. Multimedia (video, animations, audio, scanned photographs and graphics) is used to **facilitate** the transfer of knowledge and learning.

The knowledge contained in the system includes:

- the different types of distortion and when they occur;
- the factors in welding affecting distortion;
- practical steps to reduce distortion;
- precautions for specific welding and cutting situations;
- actions to correct distortion after welding.

The system also includes a series of quiz type questions that will test the user's understanding of distortion.

Simulation

MAGSIM simulates the GMA welding process calculating the weld shape and the thermal cycle at various points along the weld (7). Graphics is used to display the cross section of the weld and a 3-D view is used to visualize the simulation results; the calculated thermal cycle and shape of the **weld pool.** The program can be used to predict the weld quality for selected welding parameters with **tolerances**. For **butt and fillet joints** in CMn and alloy steels, welding parameters can be optimized for a specific task.

Education and Training

WELDING FUME TUTOR is a CD ROM based multimedia training course aimed at educating welders, **supervisors** and welding engineers on the risks to health that could arise from **inhalation of welding fume**. The program can also be used for training welders in fume control techniques and use of **extraction equipment**. The information contained is based on **statutory regulations**, expert knowledge and practical experience. The program is interactive and combines video clips, animated sequences, audio, scanned photographs and graphics.

Welding engineering IT on the WWW

The main use of the Internet by engineers is to search for technical information, exchange technical data and to purchase products. Most of the sites have hypertext links to many more sites that contain related information on, for example, engineering, materials, manufacturing and non destructive testing. TWI is typical of the organizations offering technical information. The information available includes technical data sheets, "best practice" guides, directory of suppliers, standards information, abstracts of research projects.

The TWI Web site is accessed by over 6000 users each month and approximately half of the users are from the USA. The most requested pages relate to the technical information.

As advertising is freely practiced on the WWW, most commercial companies have Web pages devoted to the advertising and marketing of their products. The companies can make text, pictures, sounds and video available on their Web pages using the hypertext mark-up language. The ESAB WWW site (http://www.esab.se) contains the following PC programs available from Business Area Consumables:

WELDCOST - selection of welding process from economic/productivity calculations;

WELDOC - storage and retrieval of welding procedure specifications;

PREHEAT -calculation of preheat temperature;

EQUIST -steel grades and their equivalents;

STAR - stainless steel consumables;

CONQUEST - range of steel grades and their recommended consumables;

THE SCHAEFFLER-DELONG—WRC'92 analysis program is particularly useful to welding engineers and metallurgists in that it can be used to select a suitable consumable when welding dissimilar metals, predict the microstructure of the resulting weld, warn about possible metallurgical risks on welding, build a database of commonly used metals and their consumables.

A typical screen display may show the composition of the resulting weld metal produced when welding 15 Mo 3 steel to AISI316L stainless steel using the type OK 67.60 consumable. The diagram may also contain a useful warning on the zones of weld metal compositions (nickel and chromium equivalents) in which cracking is likely to occur.

Vocabulary

simulation	моделирование, имитация, воспроизведение
word processing	электронная обработка текста
software	программное или математическое обеспечение, программные средства
storage	хранение
CD ROM	Compact Disk Read-Only Memory – компакт-диск
consumable	расходные материалы
fatigue	усталость (материала)
rod	электрод
reel of wire	моток проволоки
parent metals	основной металл
complementary	дополнительный, добавочный
traceability	отслеживаемость
NDT	nondestructive test испытание без разрушения образцов
distortion	деформация, коробление
tolerance	тех. допуск, допустимое отклонение
butt joint	стыковое соединение, соединение встык
fillet joint	шпоночное соединение
supervisor	инспектор
welding fume	сварочный дым, сварочные аэрозоли
extraction equipment	вытяжное (вентиляционное) оборудование
regulations	правила, устав, нормы; инструкция
to gain access	получать доступ

Writing

16 Imagine you are given a task by the head of a big welding company to make a research and decide whether it's worth while introducing computers into the production process. Write a report to your boss mentioning the following points.

- What kind of software is available for welding engineers?
- How can welders get access to welding related information?
- How can computers improve the work of welders?
- What welding procedures can be best computerized?

Reading 4

17 Read the first part of the article ***Moving Weld Management from the Desk to the Desktop*** *and say if the following is true or false.*

1. There are a lot of computer programs for welding engineers.
2. It is more important to have a deep understanding of software development than the technology being computerized.
3. Most existing software systems in the fabrication industry are tools for large companies.
4. The first database management systems could not create new procedures for new application.

Moving Weld Management from the Desk to the Desktop

Part 1. Computers as Welding Expert Systems

Welding engineers have managed welding procedures and welder performance qualifications using computers for some years now. Engineers now readily access vital information - no more searching through piles of paper. They can easily develop procedures and qualifications through on-screen editing, get advance warning of expirations and produce a professional-looking document in the end. Most fabricators now have local or wide area networks so sharing information between key personnel is easier than ever before. Computers can integrate management of procedures and qualifications with production weld information and quality control (QC) data, and so the benefits abound.

Computers have always been good at storing, sorting and searching through large amounts of data, making them suitable for pure **database** applications. Such applications have required the user to know certain parameters, with little or no help from the software. In welding, such systems have been used for managing welding procedures and welder performance qualification. But, to date, most have had limited, if any, expertise in welding.

The problem with building expertise into software it is necessary to have a deep understanding of both software development and the technology being computerized. In the welding industry, this includes metallurgy, engineering, production, quality control and standards. Standards are particularly important, as many aspects of fabrication are specified via national and international standards, such as ASME IX, AWS D1.1, EN 287/288 AND ISO 9000.

Software houses with no depth of welding expertise or engineers with no depth of software development skills both find it difficult to develop expert welding systems. It may be possible for individual engineers to develop software, but long-term support is difficult at best, and in most cases impossible. For storage of large amounts of information, where considerable time is invested in entering the data, long-term support is critical.

In addition, most existing software systems in the fabrication industry are tools for individuals, not for large parts of organizations, because, until recently, most organizations have simply not had the infrastructure to allow information to be distributed electronically. E-mail has helped change this. Electronic mail has driven most fabricators to use local and wide area networks. These networks make it possible to share welding procedures or welder approvals across a company via a multi-user software system.

The management of welding procedures is one of the most time-consuming jobs of a welding engineer. Creating, verifying and approving new procedures and checking, adapting and approving existing ones take a ling time. Plus, searching for existing procedures for new production welds requires expert skills. Consequently, this was one of the first welding engineering tasks to be computerized.

The first welding procedure database management systems were simply electronic **filing cabinet**s. They used the speed of data sorting that computers could offer to make searching for existing procedures much quicker. Documents could be copied and edited to create new documents quickly and easily. What they could not easily do, however, was help the welding engineer create new procedures for new application.

The sources of such information are wide and disparate. They comprise standards (welding and application), consumable and base material handbooks, technical literature; most difficult of all to computerize is experience. To build all this into a computer program would be impossible without a wide knowledge of the sources available.

18 Read the second part of the article and answer the questions.

1. What can Weldspec 4 do?
2. What are the main sources from which Weldspec 4 originated?
3. How can Weldspec 4 be updated?
4. How is data entered into the system?
5. In what ways can the system produce reports?
6. What time-consuming tasks can Weldspec 4 perform with a click of a button?
7. What is the difference of a usual welding software from an expert system?
8. What, in your opinion, computers will never be able to do in welding?

Part 2. Weldspec 4

Taking all this into account, The Welding Institute (TWI), Cambridge, U.K., and C-spec, Pleasant Hill, California, have collaborated to develop a new version of Weldspec. Weldspec 4 has been designed to help the welding engineer write and draft new welding procedures while still giving the benefits of speed and editing of existing procedures in Microsoft Windows®. The software comes from many backgrounds, including the following:

- Worldwide welding and application standards from such organizations as ASME, AWS, European standards and API;
- Industry practice in developing, qualifying and using welding procedures;
- Typical interactions between customer, fabricator and inspector;
- Welding engineering and metallurgy;
- Software development and knowledge representation techniques.

Software so vitally based on knowledge and recommendations from standards needs to be frequently updated; indeed, ASME IX is updated annually. Because anything hard coded within software is difficult to change, Weldspec's knowledge base is stored externally to the main program so it can be modified.

Managing welder performance qualifications (WPQs) is very similar to welding procedures: Both are designed by standards. Variables that must be recorded, the extent of approval given by a test and the destructive and nondestructive examination (NDE) regimes are specified in national and international standards.

However, unlike welding procedures, WPQs are only valid for a specified time without practice or additional testing. Certificates expire, so the fast sorting capability of computers is even more beneficial. By integrating another program called Welderqual 4 with Weldspec 4 to share a database of welder details, WPQs can be created directly from welding procedures.

An integrated software system such as Welding Co-ordinator can help. Welding Co-ordinator is designed to be used live to manage fabrication as it is progressing. It is usually based around an electronic weld map, weld data sheet or weld schedule, into which data are entered as welds are designed, engineered, welded and tested. The weld map would also usually have some space for approval, either weld by weld, or once a project or structure has been completed. The Figure below shows a detail of a typical weld map for a fabricator in the **power generation** industry.

Data are usually entered into the system from four functions, as follows:

At the design stage, where information such as the weld ID number and other design parameters (material type, thickness, joint type, etc.) are entered.

At welding engineering, where a procedure is assigned. It may also be possible to identify suitable welders or classes of welders qualified to make the weld, although this is more likely to be done at the production stage. At production, where the completion of a weld is registered (usually by entering the date) and visual inspection carried out and approved.

The system also gives instant progress reporting. Anyone with access to the system can see how fabrication is progressing. This may be simply by looking at the weld data sheet on screen or by explicitly programmed progress reports. These can identify **bottleneck**s (by, for example, comparing the number of welds competed with the number of weld radiographed), or help to produce reports for stage payments in large projects.

It also provides automatic assignment of welding procedures and welder. If enough information is supplied at the design stage, the system searches through a database of procedures for suitable welding procedure specifications (WPSs). This may be a single WPS of a number from which to choose from, with a click of a mouse button. Having chosen a suitable WPS, the system searches through WPQs for qualified welders. If necessary, the system can list welders in order of their certificate expiration dates; with those due to expire soonest at the top of the list; so maximum benefit can be made of extending their qualification.

The system can also produce reports on repair rates per welder (to identify training requirements), by procedure (to highlight **defect-prone** procedures) or by any other measure, providing the relevant data are recorded.

It also automatically generates document packs on completion of a project. A very time-consuming task manually, it's again ideally suited for computerization. With the click of a button, the system can print the weld maps for a project, along with all the WPSs used (with backup procedure qualification records (PQRs) if necessary and all the WPQs, which are updated automatically based on satisfactory production welds. In addition, if NDE specifications have been used to report testing, the system can print relevant NDE reports as well. This information can also be archived on CD.

It can also instantly trace production welds to the information backing them up. If the inspector wants to see a WPS that was used on a weld, or proof that the welder was suitably qualified, this can be done with the click of a button. This can be especially useful while inspection a structure after a number of years of service. If a defect is found, the engineer can access the original WPS, for repair purposes, or the NDE report, to see if evidence of the defect was present at testing.

Vocabulary

storage	хранение
database	база данных
filing cabinet	1) шкаф для хранения документов; 2) картотека, каталог
power generation	производство электроэнергии
bottleneck	узкое место

19 Make an abstract of the two parts of the article ***Moving Weld Management from the Desk to the Desktop***

Revision

20 Make a short description of Friction Stir Welding method using the following key words.

Fusion, filler material, aluminium and its alloys, plates and sheets, frictional heating and mechanical deformation, rotating tool, tool, shoulder, pin, work piece, heat generation, microstructure of a friction-stir weld, applied pressure, characteristics of the material, withdrawal of the tool, onion-ring structure, HAZ, integral weld.

PART 6. HEALTH, SAFETY AND ACCIDENT PREVENTION

Lead in

1 Discuss in the group.

1. Do you think welding is a dangerous/hazardous profession?
2. What type/types of welding do you consider the most/least hazardous? Why?

Reading 1

2 Look through the text ***Health Risks of Welding Fume/Gases and*** *list the risks generated during welding.*

Health Risks of Welding Fume/Gases

Welding fume is a mixture of airborne fine particles. Toxic gases may also be generated during welding and cutting.

Particulate fume

More than 90 % of the particulate fume arises from vaporisation of the consumable electrode, wire or rod as material is transferred across the arc or flame. The range of welding particles size is shown in relation to the more familiar types of dust and fume. The respirable fraction of particles (especially less than 3μm) are potentially the more harmful as they can penetrate to the innermost parts of the lung.

Gases

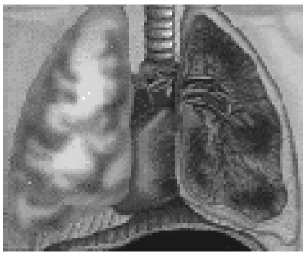
Gases encountered in welding may be:
- Fuel gases which, on combustion, form carbon dioxide and, if the flame is reducing, carbon monoxide;
- Shielding gases such as argon, helium and carbon dioxide, either alone or in mixtures with oxygen or hydrogen;
- Carbon dioxide and monoxide produced by the action of heat on the welding flux or slag;
- Nitric oxide, nitrogen dioxide and ozone produced by the action of heat or ultraviolet radiation on the atmosphere surrounding the welding arc;

- Gases from the degradation of solvent vapours or surface contaminants on the metal.

The degree of risk to the welder's health from fume/gases will depend on composition, concentration, the length of time the welder is exposed, the welder's **susceptibility**.

Health hazards from particulate fume

The potential hazards from breathing in particulate fume are:



1. Irritation of the respiratory tract. Fine particles can cause dryness of the throat, **tickling**, **coughing** and if the concentration is particularly high, tightness of the chest and difficulty in breathing.

2. Metal fume fever. Breathing in metal oxides such as zinc and copper can lead to an acute **flu**-like illness called 'metal fume **fever'**. It most commonly occurs when welding galvanised steel; symptoms usually begin several hours after exposure with a thirst, cough, headache, sweat, pain in the **limbs** and fever. Complete recovery usually occurs within 1 to 2 days of removal from the exposure, without any lasting effects.

3. Longer term effects. The continued inhalation of welding fume over long periods of time can lead to the deposition of iron particles in the lung, giving rise to a benign condition called **siderosis**. There is evidence that welders have a slightly greater risk of developing lung **cancer** than the general population. In certain welding situations, there is potential for the fume to contain certain forms of chromium and/or nickel compounds - substances which have been associated with lung cancer in processes other than welding. As yet, no direct link has been clearly established. Nevertheless, as a sensible precaution and to minimise the risk, special attention should be paid to controlling fumes which may contain them.

Additional hazards

A number of other specific substances known to be hazardous to health can be found in welding fume such as barium and fluorides which do not originate from the metal. If the metal contains a surface coating, there will also be a potential risk from any toxic substances generated by thermal degradation of the coating.

Health hazards from gases

The potential hazards from breathing in gases during welding are:

1. Irritation of the respiratory tract. Ozone can cause delayed irritation of the respiratory tract which may progress to bronchitis and occasionally pneumonia. Nitrogen oxides can cause a dry irritating cough and **chest tightness**. Symptoms usually occur after a delay of 4 to 8 hours. In severe cases, death can occur from **pulmonary oedema** (fluid on the lungs) or **pneumonia**.

2. Asphyxiation. There may be a risk of asphyxiation due to replacement of air with gases produced when welding in a workshop or area with inadequate ventilation. Special precautions are needed when welding in confined spaces where there is the risk of the build up of inert shielding gases. Carbon monoxide, formed as a result of incomplete combustion of fuel gases, can also cause asphyxiation by replacing the oxygen in the blood.

Establishing safe levels of fume in the workplace

The COSHH Regulations* require that **exposure** is controlled below specific limits. The limits, known as occupational exposure limits, are detailed in EH 40 which is revised periodically. The majority of limits listed are for single substances. Only a few relate to substances which are complex mixtures; welding fume is one of these. It has an occupational exposure limit but account must also be taken of the exposure limits of the individual constituents. So, in considering what would be safe exposure levels to welding fume, not only should exposure be controlled to within the welding fume limit but also the individual components must be controlled to within their own limits. The assessment of exposure to fume from welding processes is covered in EH 54.

Substances may have a maximum exposure limit (MEL) or an occupation exposure standard (OES).

A MEL is the maximum concentration of an airborne substance to which people may be exposed under any circumstances. Exposure must be reduced as far as is reasonably practicable and at least below any MEL.

An OES is the concentration of an airborne substance, for which (according to current information) there is no evidence that it is likely to cause harm to a person's health , even if they are exposed day after day. Control is thought to be adequate if exposure is reduced to or below the standard.

The OESs and the MELs of some of the substances found in welding fume are listed in Table below; the absence of other substances from this list does not indicate that they are safe.

Chart 2

Occupational Exposure Limits

Substances Assigned a Maximum Exposure Limit	**8hr TWA**	**15 min STEL**
Beryllium	0.002 mg/m^3	
Cadmium oxide fume (as Cd)	0.025 mg/m^3	
Chromium VI compounds (as Cr)	0.05 mg/m^3	
Cobalt	0.1 mg/m^3	
Nickel (insoluble compounds)	0.5 mg/m^3	
Substances Assigned an Occupational Exposure Standard		
Welding fume	5 mg/m^3	
Fluoride (as F)	2.5 mg/m^3	
Iron oxide, fume (as Fe)	5 mg/m^3	10 mg/m^3
Zinc oxide, fume	5 mg/m^3	10 mg/m^3
Manganese, fume (as Mn)	0.5 mg/m^3	
Ozone		0.2 ppm
Nitric Oxide	1 ppm	
Nitrogen dioxide	1 ppm	
Chromium III compounds (as Cr)	0.5 mg/m^3	
Barium compounds, soluble (as Ba)	0.5 mg/m^3	
Carbon monoxide	50 ppm	300 ppm
Copper fume	0.2 mg/m^3	

If the fume contains only substances such as iron or aluminium which are of low toxicity, an 8 hour (TWA) OES of 5mg/m3 applies; this figure is the average concentration of particulate fume that should not be exceeded in an 8 hour day.

The Control of Substances Hazardous to Health (COSSH) Regulations 2002 require employers to monitor the safe use of chemicals and hazardous substances at work. It requires them to: control exposure to hazardous substances to prevent ill health both now and any future cumulative effects they may have, protect both employees and others who might be exposed, compile records of employees using these materials, supply employees with suitable personal protective equipment.

Vocabulary

irritation	раздражение
respiratory tract	дыхательные пути
susceptibility	Чувствительность, восприимчивость
fever	жар, лихорадка; какое-л. заболевание, основным симптомом которого является очень высокая температура
tickling	першение (в горле)
chest tightness	стесненное дыхание
flu	грипп
coughing	кашель
limb	конечность (человека или животного)
siderosis	сидероз
pneumonia	воспаление легких, пневмония
pulmonary	
oedema	отек легких
asphyxiation	удушье
exposure	подвергание какому-л. воздействию; выставление, оставление на солнце, под дождем и т. п.
cancer	рак

3 *Read the text carefully and answer the following questions.*

1. What is the difference between welding fume and welding gas?
2. What does the major part of the particulate fume arise from?
3. What does the degree of risk to the welder's health from fume or gases depend on?
4. Under what condition is control over the exposure of welders to hazardous fumes or gases considered adequate?
5. Do the COSHH Regulations state only single substances?

4 Say if the following is true or false. Correct the false sentences.

1. The smaller the particles the more harmful the fume is.
2. The risk to the welder's health from fume or gases depends on the welding arc.
3. Welders have lung cancer more often than the general population.
4. Asphyxiation may happen due to inadequate ventilation.
5. Metal fume fever is an incurable illness.

5 Complete the following sentences.

1. Argon is a … gas.
2. Particulate fume is very … for man’s health.
3. When exposed to particulate fume of high concentration for a long time, a welder may … .
4. Welding galvanised steel may cause … .
5. Asphyxiation may happen due to … .
6. To minimise the risk, special attention should be paid to controlling fumes which may contain chromium or … compounds.
7. In case of metal fume fever, …. recovery occurs soon after removal of the welder from the exposure.
8. … is a disease caused by fluid on the lungs.
9. MEL means maximum … limit.
10. OES is … exposure standard.
11. Gases encountered in welding are … .

Reading 2

6 Read the text ***Safety and Scheduled Maintenance Protect Your Welding Assets*** *and say if you follow all the instructions during welding.*

Safety and Scheduled Maintenance Protect Your Welding Assets

Q: What can I do to avoid electrical shocks?

A: Wet working conditions must be avoided, because water is an excellent conductor and electricity will always follow the path of least resistance. Even a person's perspiration can lower the body's resistance to electrical shock. Poor connections and **bare spot**s on cables further increase the possibility of electrical shock, and therefore, daily inspection of these items is recommended. Equipment operators should also routinely inspect for proper **ground connections**.

Q: How can I inspect and maintain my wire feeder?

A: Periodically inspect the electrode wire drive rolls. If dirty, remove the drive rolls and clean with a wire brush. Deformed drive rolls should be replaced. Drive rolls should be changed, adjusted or cleaned only when the wire feeder is shut off. In addition, check the inlet and outlet guides and replace if they are deformed from wire wear. Remember that when power is applied to a wire feeder, fingers should be kept away from the drive roll area.

Q: What are some important electrode safety considerations?

A: Welding power sources for use with MIG and TIG welding normally are equipped with devices that permit on/off control of the welding power output. If so, the electrode becomes electrically hot when the power source switch is ON and the welding gun switch is closed. Never touch the electrode wire or any conducting object in contact with the electrode circuit, unless the welding power source is off. Welding power sources used for shielded metal arc welding (SMAW or Stick welding) may not be equipped with welding power output on/off control devices. With such equipment, the electrode is electrically hot when the **power switch** is turned ON.

Q: How should I store my gas cylinders?

A: Cylinders should be securely fastened at all times. Chains are usually used to secure a cylinder to a wall or cylinder cart. When moving or storing a cylinder, a threaded protector cap must be fastened to the top of the cylinder. This protects the valve system should it be bumped or dropped. Cylinders should not be stored or used in a horizontal position. This is because some cylinders contain a liquid which would leak out or be forced out if the cylinder was laid in a flat position. Also, welding guns and other cables should not be hung on or near cylinders. A gun could cause an arc against the cylinder wall or valve assembly, possibly resulting in a weakened cylinder or even a **rupture**.

Q: How can I tell if my regulator is faulty?

A: The following symptoms indicate a faulty regulator:

Leaks - if gas leaks externally.

Excessive creep - if delivery pressure continues to rise with the downstream valve closed.

Faulty gauge - if gauge pointer does not move off the stop pin when pressurized, nor returns to the stop pin after pressure release. Do not attempt to repair a faulty regulator. It should be sent to your designated repair center, where special techniques and tools are used by trained personnel.

Q: What are some tips for a safe welding environment?

A: The area surrounding the welder will be subjected to light, heat, smoke, sparks and fumes. Permanent booths or portable partitions can be used to contain light rays in one area. The heat and sparks given off are capable of setting flammable materials on fire. Therefore, welding should not be done in areas containing flammable gases, vapors, liquids or dusty locations where explosions are a possibility. Metals with plating, coatings or paint that come near the region of the arc may give off smoke and fumes during welding. These fumes may pose a health hazard to the lungs, therefore an **exhaust hood** or booth should be used to remove fumes from the area. When welding in **confined spaces**, such as inside tanks, large containers or even compartments of a ship, toxic fumes may gather. Also, in an enclosed room, breathable oxygen can be replaced by shielding gases used for welding or purging. Care must be taken to ensure enough clean air for breathing. In many companies, it is routine to provide welders with air masks or self-contained breathing equipment.

Q: How should an operator dress for optimum safety?

A: Gloves and clothing should be flame-resistant. Clothing made from a dark-colored, tightly woven material is best suited for welding. Gauntlet-type leather gloves should be worn to protect the hands and wrists. Shirt collars and shirt cuffs should be buttoned, and open front pockets are not advisable as they may catch sparks. Also, operators should never store matches or lighters in their pockets. Pants cuffs are not recommended, as they will also catch sparks. Tennis shoes do not qualify as adequate foot protection. High-top leather shoes or boots are absolutely necessary.

Vocabulary

bare spot	оголенный участок
wire feeder	механизм подачи (электродной или присадочной) проволоки
ground connection	1) заземление, замыкание на землю 2) соединение на корпус
power switch	переключатель мощности
rupture	1) пробой (изоляции); 2) излом, разрушение, разрыв
confined space	замкнутый объём, замкнутое пространство
exhaust hood	вытяжной шкаф; вытяжной колпак

7 Find the English equivalents in the text for the following word combinations:

путь наименьшего сопротивления, поражение электрическим током, соображения безопасности, защитный колпак, обученный персонал, наносить вред, грубое обращение.

Speaking

8 *Answer each of the questions in text 6 in just one sentence.*

Model: **Q: What can I do to avoid electrical shocks?**
A: To avoid electrical shocks you should not operate in wet working conditions check your circuit for poor connections and bare spots.

Reading and speaking

9 *Below is a general engine drive routine daily maintenance schedule. Read the information in the chart and say what a welder should do in terms of maintenance*

- once a working day;
- once a week;
- once a month.

Chart 3

Maintenance Schedule Chart

8 Hours	Wipe up oil and fuel spills immediately Check fluid levels (oil & fuel) Service the air filter (refer to engine manual for specifics)
50 Hours	Service air filter element (refer to engine manual for specifics) Clean and tighten weld terminals
100 Hours	Change oil Change oil filter (refer to engine manual for specifics) Clean and tighten battery connections Clean cooling system (refer to engine manual for specifics)
200 Hours	Replace unreadable labels (order from parts list) Replace fuel filter Check valve clearance (refer to engine manual for specifics)
250 Hours	Check and clean spark arrestor
500 Hours	Tape or replace cracked cables Clean/Set injectors (refer to engine manual for specifics)
1000 Hours	Blow out or vacuum inside equipment. During heavy service, do this monthly.

10 *Answer the following questions.*

1. What should be inspected daily by a welding operator to avoid electric shock?

2. What should be cleaned/ changed/ replaced while maintaining wire feeder?
3. Why shouldn't you touch the electrode wire when the welding power source is on?
4. Why shouldn't cylinders be stored or used in a horizontal position?
5. Should you try to repair a faulty regulator yourself?
6. What are booths and partitions used for?
7. What shouldn't a welder store in his pockets?

11 Summarize the information of the text using the following incomplete sentences as a plan.

1. To avoid electrical shocks a welder should/shouldn't… (inspect, repair, etc.)
2. The following things should be remembered when inspecting and maintaining wire feeder … .
3. To use and store electrodes safely, one should/shouldn't … .
4. Gas cylinders should be stored in the following way: … .
5. If the regulator is faulty, you can observe the following: … .
6. Safe welding environment is obtained by … .
7. Welding operators should be dressed in … .
8. To keep welding equipment running for decades, operator should do some operations on a regular basis, such as … .

Revision

12 Describe in detail the welding procedure which you are most experienced in. Follow the plan.

- the task to do
- the equipment required
- work stages
- safety measures
- quality control

PART 7. ADVANCED TECHNOLOGIES AND THE FUTURE OF WELDING

Lead-in

1 Read the two opinions about the future of welding and say which one you support.

The future looks promising for welding. It remains and will continue to be a productive, cost-effective manufacturing method.

As far as design will be more and *more efficient there will be no* need in joining parts by means of welding and it will see decline in use.

Reading 1

2 You will read the text ***"The past, present and future of aerospace join processes"****. Before you read suggest your answers to the following questions.*

1. Why can welding be necessary on board of a spaceship?
2. What kinds of welding methods, in your opinion, are good for use in space?
3. Why is welding in space such a difficult task?

3 Read the text again and say what events relate to:

- the past
- the present
- the future

Fill the table. Some examples are given.

The past	The present	The future
verifying the possibility of thermal-cutting and welding in space	testing in a flying laboratory	completely new methods of nondestructive testing and diagnosing welded structures

Space-Age Welding:
The Past, Present and Future of Aerospace Join Processes

By B.E. Paton
April 10, 2003

On Oct. 16, 1969, astronauts performed the world's first welding and cutting experiment in a depressurized compartment. In flight aboard the Soyuz 6 spaceship, they tested three welding processes with a semiautomatic Vulkan unit (see Figure below): consumable electrode arc in vacuum, low-pressure plasma, and electron beam welding. They studied how to weld aluminum and titanium alloys and stainless steel. They verified the possibility of thermal-cutting these materials and investigated the behavior of molten metal and features of its solidification.

This experiment convinced experts that they could use automatic welding to produce permanent, tight joints in space. They expanded this work with a series of investigations conducted under short-time microgravity conditions in flying laboratories and space simulation test chambers. In 1973 NASA experts conducted a flight experiment with electron beam cutting, brazing, and welding in the Skylab orbital station.

Space welding technologies have advanced since then. In-space repair and construction of space facilities and their equipment and **instrumentation** were defined in the 1980s. Another major area identified was producing advanced materials in space with new or improved properties using different heat sources.

Over the years scientists and specialists had to address construction of various experimental space vehicles, namely, orbital and interplanetary stations, radio telescopes, antennas, **reflecting shields**, and helio power generation systems - in outer space.

In addition to the original problems of assembly and erection in outer space, as well as their view of how long these vehicles would be used and increases in the vehicles' weight and dimensions, specialists focused more attention on **preventive maintenance** and repairs.

Initial Welding Experiments

The first welding experiments conducted in space demonstrated that arc welding processes, which were widely accepted on earth and at first were promising, had unfavorable characteristics in space, such as unstable, weakly constricted **arc discharge**; unstable **globular** transfer; and increased weld porosity.

During experimental **retrofitting** in simulation facilities-chiefly in space simulation chambers placed in flying laboratories-the difficulties related to these characteristics were successfully resolved. Specialized welding equipment and techniques also were developed for this purpose, and the required welding consumables often were selected from those used in the aerospace industry.

However, it was clear to space system developers that almost all maintenance and repair of long-term flying vehicles - for which neither the scope of work needed nor the components to be repaired and restored are known in advance-had to be performed manually with only partial mechanization. This increased specialists' interest in studying the possibility of manual welding in space, which led them to consider which of the existing welding processes to use.

Welding processes such as electron beam, consumable and nonconsumable electrode arc in vacuum, flash-butt, hollow cathode, and helio welding were tested in vacuum chambers and in flying laboratories at different stages of experimental studies in the 1970s and 1980s.
Technology and material versatility and minimal power consumption ultimately were deciding factors that led them to choose the electron beam process. This process allowed technicians to perform operations that could be required to produce a permanent joint in open space: heating, brazing, welding, cutting, and coating **deposition**.

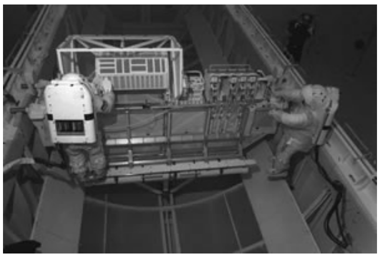
But selecting this process didn't solve all the problems. As investigations progressed, the number of problems, technical and psychological, increased. An opinion existed that this process, which involves high-accelerating voltage, the possibility of X-ray radiation from the weld pool, and manipulation of a sharply focused electron beam, couldn't be done manually.

A series of experiments in a ground-based, manned space simulation chamber enabled the engineers to solve the key technological and hardware issues and develop a flight sample of an onboard electron beam hand tool. In 1984 and 1986 this tool was successfully tried out on the outer surface of the Salyut 7 orbital complex (see Figure above).

Based on new engineering systems that corrected technical parameters and suppositions from the test engineers and crews during experiments in the Salyut station, engineers developed a new electron beam hand tool in the 1990s. The tool passed lengthy testing at NASA's Marshall Space Flight Center and Johnson Space Center. During testing in a flying laboratory and at zero buoyancy, as well as in a manned space simulation test chamber in Russia, the developers were able to solve almost all the technical and procedural problems with the tool.

Further Aerospace Welding Exploration

Almost 40 years' experience of technology developments and their application leads to the conclusion that in this new century, major, complicated space work will have to be addressed. Welding technologies will be of tremendous importance.



Such technologies are partially in place, but further space exploration will require developing new welding, cutting, brazing, and coating processes. New exotic materials will be introduced in the new century, and their processing and joining will require completely new technologies.

A number of space operations can be performed remotely, using robots and manipulators.

Welding in space might become widely accepted only if completely new methods of nondestructive testing and diagnosing welded structures can be developed. This can be supported by data banks that allow automatic selection of the process and computer simulation.

Laser applications in space, including such hybrid processes as laser-plasma and laser-arc welding, offer promise, especially diode lasers. Friction welding and resistance seam-roller welding also are of interest.

Advanced space systems will continue to be developed both on the ground and in orbit. New welding and related processes and technologies will have an important role in those developments.

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Vocabulary

instrumentation	оснащение инструментами, приборами, аппаратурой, комплект инструментов, аппаратура
reflecting shield	отражающий экран
preventive maintenance	профилактическое обслуживание
arc discharge	дуговой электрический разряд
globular	шаровидный, сферический, сфероидальный, шарообразный
retrofitting	подгонка, настройка
deposition	осаждение

5 *Say if the following is true or false.*

1. The world's first welding and cutting experiment was carried out in the outer space.
2. Thermal-cutting of aluminium, titanium alloys and stainless steel is impossible in space.
3. Only automatic welding is of importance for aerospace.
4. A flight sample of an onboard electron beam hand tool was produced as a result of series of experiments.
5. Space welding is used for maintenance and repair purposes.

6 *Translate the following sentences into English.*

1. На борту космического корабля исследователи изучали поведение расплавленного металла и особенности его кристаллизации в условиях кратковременной микрогравитации.
2. Технологии космической сварки шагнули далеко вперед.
3. Одна из задач, решаемых с помощью сварки в открытом космосе, – профилактическое обслуживание и ремонт оборудования космического корабля.
4. Разнообразие используемых материалов и невысокая энергоемкость оборудования являются решающими факторами, обусловливающими возможность использования сварки в открытом космическом пространстве.
5. Дальнейшее освоение космического пространства потребует усовершенствования практически всех видов сварочных технологий, а также резания, пайки и нанесения покрытий.

6. Специфика используемого на космических кораблях оборудования обусловливает необходимость использования, прежде всего, ручной сварки при частичной автоматизации процесса.
7. Электроннолучевой ручной сварочный аппарат прошел успешные испытания на орбитальном комплексе в условиях открытого космоса.
8. Использование новейших материалов в следующем столетии потребует разработки совершенно новых технологий получения неразъемных соединений.

Reading 2

*7 You will read the text **What Is Orbital Welding.** Before you read think and say why this type of welding is called "orbital". Read the opening paragraph and check your supposition.*

Read the text and say what the main advantages of this method are.

What Is Orbital Welding

The term Orbital-Welding is based on the Latin word ORBIS = circle. This has been adopted primarily by aerospace and used in terms of Orbit (noun) or Orbital (adjective) for the trajectory of a man-made or natural satellite or around a celestial body. The combination Orbital Welding specifies a process by which an arc travels circumferentially around a work piece (usually a tube or pipe). The concept Orbital Welding is basically a loosely defined term that is usually used for processes only, where the arc is travels at least 360 degrees around the work piece without interruption. Consequently, processes, which interrupt the full 360-weld sequence such as for better puddle control (often used for MIG/MAG welding, using the down-hand welding sequence in 2 half-circles), can not truly be called orbital welding.

Possibilities and Limitations

From welding terminology Orbital Welding belongs to the category *semi-mechanized (TIG-) welding.* Because of the need for good control of the weld puddle, the Orbital-Welding process is only practiced with the TIG process and relevant rules like selection of gases, cleanness, weldability of specific materials and consequential mechanical strength specifications such as tensile and bend loading, are very important.

Orbital-welding is presently used whenever the quality of the weld joint has the highest priority. These demands are not only limited to mechanical strength and X-ray qualification, but also to the important aspects of the aesthetics of the weld seam. For any users a uniform, flat and smooth root-pass is the main reason for using this process. Consequently, it is favoured in the following areas: chemical industry, pharmaceutical industry, bio-technology, high-purity water systems, semiconductor industry, aircraft- and aerospace industry. Moreover, because of the weld joint's uniform outside shape and almost complete absence of need for any post-polishing, Orbital-welding is even used for bends on door-handles, hand-guards, or in dead foot-elements for champagne-glasses! Interested applicants for this technology should certainly note that they have to confirm a couple of indispensable premises.

The following presents the basic rules for this process, valid for all manufacturers and systems.

Even knowing that some competitors are announcing features, which would potentially violate the basic physical laws of nature and knowledge, moreover, making promises and statements which are at least detected as impossible to meet when the welding system must work under high duty-cycle production conditions. Indiscriminate and exactly defined dimensions with tolerances must be thorough and complete. The much liked standpoint, that the welded tubes and pipes are in accordance to DIN or ASME standards are not acceptable criteria. These qualifications only define tolerances in percentage to the wall thickness relating to pressure loading and not to weldability using the Orbital-Welding-Process.

For the Orbital-Welding-Process absolute tolerance values are necessary, and furthermore, the more complicated the application, the tighter the tolerances must be. This means, that for an easy application like welding a stainless steel tube of 53 x 1,5 mm, a tolerance in alignment of about 0,5 mm (about 30% of the wall thickness) can be compensated, but for much more critical applications like welding a carbon-steel pipe of 114,3 x 3,6 mm, the same percentage can result in unacceptable weld quality. Therefore, the question of acceptable tolerances should be researched and defined for each application individually.

That Orbital-Welding can be used successfully and economically is proven by the constantly increasing number of users. Field experience has shown that Orbital-welding can be justified based upon economic reasons alone, where the welds can be done in squared-butt no-gap preparation utilizing a single pass. With advanced digital welding systems this is possible up to a wall-thickness of 4 mm, and with welding systems with lower performance capabilities (limited levels, no pulse-synchronized cold-wire-feeding), up to 3 mm.

Joint preparation is simple but requires high quality with an exact 90\'b0 angle to the tube/pipe axis; a high quality saw cut is usually enough.

Of course, the joints should be deburred and cleaned out of corrosion, oil, tinder, etc. With appropriate quality-demands, this should be even obvious for manual welds! The tube joints will be then fit together without any visible gap. This can be done with small autogenous tack-welds or with internal or external clamping fixtures. For larger wall-thickness it is necessary to bevel the weld-joints, far as possible in a U-shape. Since a very precise and uniform root pass is important, a weld joint is prepared with an. I.D. related and fixed bevelling-machine. Manual grinding or the use of bevelling saw blades is not precise enough for repeatable welding results. Because an Orbital-Welding job usually requires a lot in time and money, the Orbital-multi-pass-welding is not used very often and only where it is strictly recommended on quality reasons. A good qualified manual welder will, in most cases, be faster than an Orbital-welding-system. Additionally, an Orbital-system for multi-pass welds will be much more expensive and even more complicated than a system without this option.

Visual inspections of the weld-seam clone can never be sufficient as the sole criterion. Other quality controls, such as, corrosion, consistency, mechanical strength must also be considered. Also, allowed tolerances in contents of alloys on specific materials, such as sulphur content, can result in significantly different welding results, even when the material code is the same. Usually, you can expect that stainless steel materials up to 3 mm wall-thickness can be done without filler-wire. For higher wall-thickness applications, you have to decide on a case-by-case basis. In some eventualities even carbon steel can be done without filler-material, although it's even recommended on the thinner wall-thickness to use filler-wire in any way.

Vocabulary

down-hand welding	сварка в нижнем положении
celestial body	небесное тело
bend load	нагрузка на изгиб
welding sequence	последовательность сварки, порядок наложения швов
tensile load	растягивающая нагрузка
pressure load	сжимающая нагрузка, усилие сжатия
root pass	корневой шов, проход, сварка корневого шва
tolerance	допуск
manual welding	ручная сварка
post-polishing	последующее полирование

tack weld	прихваточный сварной шов, прихватка
X-ray testing (qualification)	рентгеновская дефектоскопия
high duty	жесткий режим
clamping fixture	прижимное устройство
DIN	нем. Deutsche Industrie – Normen Немецкие промышленные стандарты
ID	inside dimensions внутренние размеры
U-shape (bend)	двойной изгиб, U-образное колено, двойное колено
grinding	шлифовка
weld seam	сварной шов
filler wire	присадочная проволока
saw blade	1) пильное полотно, пильная лента; 2) ленточная пила, дисковая пила; 3) режущий диск
bevelling	1) отточка косая; 2) угол фаски; 3) фацетирование
performance capabilities	1) возможности; 2) рабочие характеристики

8 Find the English equivalents in the text for the following word combinations.

противоречить законам физики, обращаться вокруг обрабатываемой детали, иметь первостепенное значение, контроль сварочной ванны, красивый внешний вид сварного шва, гладкий и ровный проход при заварке корня шва, шлифовка вручную, приемлемый допуск, недопустимое качество сварки, квалифицированный сварщик, содержание серы, механическая прочность, искусственный спутник, система высокой очистки воды, обязательное условие.

9 Characterize orbital welding by filling in the right side of the following table.

Parameter	Description
Principle of the process	An arc travels circumferentially around a work piece (usually a tube or pipe).
Category	
Application areas	
Limitations	

10 Say if the following is true or false.

1. Orbital Welding is a process, where the arc travels at least 360 degrees around the work piece with some interruptions.
2. MIG/MAG welding, using the down-hand welding sequence in 2 half-circles, refers to orbital welding.
3. Puddle control is very important for Orbital welding.
4. The number of Orbit Welding users stays the same for a long period of time.
5. Aerospace industry is the only area of Orbital Welding application.
6. Joint preparation is not necessary.
7. Orbital-welding-system is very fast and cheap.
8. Filler-wire is used for all wall thickness applications.

Speaking

11 Describe Orbital welding by completing the following sentence.

1. The term Orbital comes from the Latin word ORBIS and means … . 2. The Orbital Welding is a process in which an arc travels … . 3. By category it belongs to … . 4. It is practiced only with … . 5.Orbital-welding is presently used in such areas as … . 6. It is used to produce … . 7. The basic rules for this process are … . 8. Absolute tolerances in Orbital-Welding Process are important because … . 9. Wall-thickness of 4 mm is possible … . 10. Joint preparation includes … . 11. Orbital-multi-pass-welding is rather expensive and its use is only justified when … . 12. Filler-wire is necessary to use only … .

Reading 3

12 You will read an interview with industry leaders who speak about future of welding.
Before you read predict which processes will be used more and which less in the future. Then read the text and compare our predictions with those in the text.

- plasma arc welding
- gas tungsten arc welding (GTAW)
- continuous wire processes (FCAW, GMAW)
- laser beam welding process
- friction stir welding

- shielded metal arc welding (SMAW)
- resistance welding gas metal arc (GMAW)
- capacitor discharge welding

Welding Forges into the Future

Answers from a survey of industry leaders give valuable feeedback on the state of welding for the year 2000 and beyond.

By Andrew Cullision and Mary Ruth Johnson

The pulse of the welding community beats strongly heading into the 21st century and overall projections for the future are generally optimistic, but a few gray clouds roam the horizon. Those sentiments were expressed by respondents to a recent Welding Journal survey. To get a firm feel for that pulse of present and future conditions in the world of welding, the Editors queried AWS Sustaining Member companies, which include producers of a variety of welded products, providers of research and design services and manufacturers of welding equipment, consumables and accessories.

The Editors would like to thank all those who took the time to put down their thoughts and ideas on paper. The responses were diverse, direct and, most of all, very interesting. Those questions and a summary of their answers are presented below.

- Do you believe welding will be used more or less in the next decade? If more, where do you see the growth? If less, why do you believe so?

The majority of respondents feel welding is here to stay and will be used more in the future, although many qualified their answers, and there were a few dissenting voices as well. Steve Sumner, manager marketing product development, Lincoln Electric Co., replied positively, "Welding will continue to be used more in the future because it has proven to be a productive and cost-effective way to join metals." He went on to speculate that "the consumer welding market will continue to provide opportunities for growth," with home improvement and the retail infrastructure to support it becoming a "burgeoning market." One respondent felt that for cost-competitive reasons industry will continue to replace mechanical joining with semiautomatic and automatic joining processes, giving a definite boost to welding. David Landon, corporate welding engineer, Vermeer Manufacturing Co., said, "More, because welding is the most effective way to join materials for structural integrity. Growth will be in alternative materials such as plastics, composites and new alloys." Phil Plotica, senior V.P., sales and marketing North America, ESAB Welding and Cutting Products, replied, "Overall, I expect welding growth will keep pace with growth in the GNP. Some specialized segments, such as aluminum, will grow faster than others, while the continuing developments in nonmetallic materials will slow some segments."

The feeling that growth will be in specialized areas was repeated often. Areas that were mentioned included welding automation, GTA welding because of the increasing need for accuracy and precision in welding new metals; GMA welding with mixed gas shielding; sheet metal industry; construction industry; infrastructure repair; transportation industry; marine structures; aerospace; and automotive, especially its use of aluminum alloys.
Some feel the growth will primarily be in countries with emerging economies, while the growth in the United States will be relatively stagnant. Terry O'Connell, V.P. sales and marketing, Genesis Systems Group, commented, "The U.S. welding market is flat to declining. Growth is expected in Mexico and other developing countries. Labor shortages in the U.S. will contribute to a steady growth in the robotic welding market." Joe Scott, president, Devasco International, Inc., echoed the sentiment, "Less in the U.S. with expectations of a slight decline in the economy, as well as the continuing transition to a service/information economy. Outside the U.S., growth is expected as economic stability returns to troubled regions and their need for infrastructure grows."

The perspective of some, though, is that welding will be used less in the future. Chris Anderson, product manager, Motoman, Inc., opined, "There will be less welding in the next decade. The number of welded products will remain the same, but designs will be more efficient to minimize the amount of welding."

- Which welding process(es) will see an increase in use and which will see a decrease in use during the next decade?

There was much speculation as to which processes would see more use in the future, but almost unanimously the process chosen for decline was shielded metal arc welding (SMAW). A very few speculated a decline in the use of gas metal arc (GMAW) and gas tungsten arc welding (GTAW).

A significant group felt the continuous wire processes (FCAW, GMAW) would experience the most use. The GTAW process was the next most mentioned. One of the reasons stated for its increase was "the need for high-quality work on thin materials."

Don Connell, welding engineer, Detroit Edison, stated, "Any process that can be automated will increase." Landon also had the same perspective, "GMAW will increase along with automation." But he also speculated, "Low-fume generating processes will increase." The concept of increased use of automation at the expense of semiautomatic operation was voiced throughout.

The laser beam welding process was mentioned for future growth, and the specialized process friction stir welding was also targeted for expanded use. Other processes mentioned for increased use were resistance welding, plasma arc welding and capacitor discharge welding.

- Do you foresee a shortage of skilled welders in your area of business during 1999; in the next decade?

Without question, the majority of replies indicated there is a shortage now and there will be a shortage in the future. The breakdown was 72% consider the situation problematic now and for the long term, 14% did not see a shortage and the remaining 14% either see no shortage now, but expect one in the future or see a shortage for 1999, but not for the future.

John Emmerson, president, Magnatech Ltd. Partnership, made a typical comment for those who see a far reaching problem, "There is a shortage of skilled welders everywhere in the world, and it is only getting worse as each year passes. Despite the fact that welding is used in virtually every industry, it seems virtually ignored as a manufacturing science. Connecticut [the state of location for Magnatech], for example, dropped its Vo-Tech welding classes in 1997. In addition, population dynamics in recent years in the U.S., Europe and Japan indicate that the next decade will see a much smaller number of young people entering the work force. This, by itself, will result in fewer welders."

ESAB's Plotica had a similar take on the situation, "There is a shortage of skilled welders now in most major market areas, and this shortage will worsen unless substantial programs are implemented to promote welding as an attractive career choice for young people."

Landon of Vermeer Manufacturing stated, "We have had a shortage for the past five years. I see no turnaround, and we will not see a turnaround until the establishment acknowledges welding as a viable career path. To meet our immediate demands, the company has developed its own welder training program. The company is also involved in proactive programs that make instructors at high schools and area colleges aware of welding as a viable career."

Connell of Detroit Edison, does not see an immediate problem, as he encouragingly stated, "There is a renewed interest in the boilermaker's welding program, bringing in a good influx of people. I don't foresee a shortage in 1999." Another respondent took a contrary view, noting a shortage of skilled welders in 1999, but projecting a leveling of demand in the next decade.

J Julio Villafuerte, director research and development, Tregaskiss, had a slightly different perspective. "The need for plain skill welders will decrease slightly with the slowdown of manual welding. However, the need for welding engineers will increase dramatically as welding automation becomes more prominent."

- Where do you see the use of welding automation heading in your industry?

If there is any one thing to bank on for the future, it is the increased use of automation in welding operations. There was an overwhelming affirmative from our respondents on this point, although it was not completely universal. The perspective of those few who did not see increased use might be expressing an influence from their particular industry. A structural steel fabricator mentioned the difficulty in automating for weldments that do not have a high degree of repetitiveness and variations in fitup and joint geometry. Another individual felt automation will not replace welding equipment for manual operations if the equipment is developed to be fast, safe and economical.

But by far the majority feel the same as Magnetech's Emmerson, who stated, "We see more and more companies of all sizes automating applications that were being done manually. Many are exploring their first use of automation, and the declining number of skilled welders will continue this trend." The lack of, or declining numbers of, skilled welders was frequently mentioned as reason for the growth of automation.

Philip Winslow, V.P. sales and marketing, Hypertherm, Inc., noted another often stated reason, "Usage will increase, primarily because of the consistency it gives to welding and cutting operations, especially with CNC (computer numerical control) and robotically controlled processes." Lincoln's Sumner was emphatic in his assessment, "Automation is the single most important growth sector in the welding industry. The drive for higher productivity and reduced costs will keep automation at the forefront." Other reasons for the increasing use of automation included safety and the effort to remove the welder from tiring, repetitive conditions and long-term exposure to fumes.

Chip Cable, president, Bug-O-Systems, isolated shipbuilding and the trucking and railroad industries as areas that will experience growth in automation. A fabricator of offshore steel structures has targeted automation for heavy tubular splices, plate girders and process piping. Small companies and job shops are anticipated to at least try robotics and CNC equipment.

- What are the strengths of the welding industry? What are its weaknesses?

Although our respondents listed plenty of strengths and weaknesses for the welding industry, Plotica of ESAB, perhaps best summed up the two most commonly held opinions. Regarding the industry's strengths, he said, "We are a well-established, mature industry, with a solid track record in technology and process advancements." And as to its weaknesses, "We are not attracting enough young people into welding careers," Plotica said. "Welding is still perceived by many as a crude and dirty process."

While many saw the industry's maturity - the reputation of welded components for being reliable and economical, the industry's commitment to research and development and the dedication of its work force - as signs of its strength, nearly as many others saw it as a weakness. They believe the industry is set in its ways and slow to change. According to one respondent, the industry's strength is that the people involved in it are "slow to change, with a show me attitude." On the other side of the coin, he said, "Its weakness is that they're slow to change even after you show them." And while a number of respondents lauded the industry's commitment to research and development, others claimed it's too esoteric and takes too long to transfer from the academic level to the factory floor.

Thomas C. Conard, president of Alexander Binzel Corp., had another take on the industry's weak spots. He noted welding is not a separate industry in and of itself but instead makes up part of many other industries. The implication here might be that welding lacks a clear-cut image and direction.

- What business improvements during the next ten years would be in your company's best interests?

As might be expected, there were nearly as many different answers to this question as there were respondents. These ranged from broad-based desires, such as a wish for growth in any field that uses metallic materials, to a more narrow focus, such as wanting increased use of electronic commerce and supply chain management. Better trained workers, improved communication techniques, designing for manufacturability and lessening the time it takes to get new products to market were all mentioned as in companies' best interests. Several persons called for increased automation.

Several respondents said a change in the government's role with regard to their operations would improve their businesses. This could occur either through less government involvement or through such things as restriction of imports, "reasonable environmental legislation that does not drive up the cost of doing business," tort reform in product liability and lower taxes.

"We spend a tremendous percentage of our income toward research and development," explained Emmerson of Magnatech. "The continuation of tax credits for small company R&D would be beneficial. We note that several of the Canadian provinces are very aggressive in nurturing technical innovation and the growth of small companies, and allow virtually all R&D expenditures to be written off against income. I believe there would be an explosion of new development and company growth if any of the state governments undertook similar tax credit programs."

- What has to be done in the future to keep the welding industry healthy?

More than 50 % of the respondents believe improving the image of welding so top students will be drawn to the industry and bettering training methods for welders and welding engineers are the keys to welding's future.

We need to "totally revise the public education system in the United States to acknowledge the trades as an acceptable alternative for students," according to Connell of Detroit Edison. This echoed the opinion of David Yapp, team leader, arc welding and automation, Edison Welding Institute, who said there needs to be "a radical change in education at all levels." He added, however, "This is not likely to happen without strong leadership and commitment."

In fact, respondents touched on a variety of aspects related to training - all with an eye toward welding's future. In the opinion of Jackie Morris, quality manager at Bender Shipbuilding & Repair Co., Inc., the level of cooperation between manufacturers and schools must improve so that manufacturers' needs are met. Genesis' O'Connell said the welding industry needs to do two things: "Enhance ease of use through technical training and technology advancement," and "concentrate on making welding the low cost, best performance choice for material joining." For the question regarding welding's weaknesses, Anderson stated it's "often not scientifically applied, which leads to overdesigned weldments and process parameters that are not optimized." Anderson touched on the topic again in answer to the above question, when he said, we must "continue to educate students on the basics of the process and how to implement it. (We must) teach the economics of welding to designers so they understand the costs of a weld."

Respondents also mentioned improved salaries for welders, staying ahead of environmental and health issues and more practical research and development as ways the welding industry can help itself stay healthy.

- Are you optimistic or pessimistic about the future of your particular industry?

Overwhelmingly, the respondents to the survey said they were optimistic about the future of their industries. In fact, 92 % of respondents indicated they are at least guardedly optimistic about the future. One respondent summed up his reasons this way: "Metallics will be around for a long time and they will need to be joined."

Much the same opinion was held by Lincoln's Sumner. "I am optimistic," he said. "Even though we are mainly tied to the steel industry, which has seen a slight decline, we have much more to learn about welding and furthering the process of joining metals. I believe products and services that the welding industry provides will continue to be in demand worldwide."

Paul D. Cunningham, president of Weldsale, indicated he was optimistic because "gains in technology via software and the Internet will help increase productivity in the U.S.A." Winslow of Hypertherm foresees a bright future: "If we improve our understanding of our worldwide customers' needs, we have a road map to unrestricted growth."

However, some respondents, such as Thomas A. Ferri, a welding process specialist with Airgas, expressed optimism while adding a word of caution. Ferri said he was "optimistic so long as we know our industry needs some changes." Morris of Bender said he was "optimistic in that shipbuilding and repair is a sound profession with an increasing market; pessimistic in that environmental restraints are greatly increasing operating costs and decreasing profit margins. There is a need for better dialog between industry and the private sector."

- During the 1990s, the trend has been for company buyouts and mergers. Do you see that trend continuing and is it healthy for your industry?

Not all of the respondents answered both parts of the above question. From the answers received, three times as many respondents believed the trend for company buyouts and mergers will continue. Several stated, however, that the pace will slow from that of the early 1990s. Besides slowing down, "a certain degree of counteraction, i.e., divestitures, may also begin to take place," according to Plotica. "For the most part, the buyouts and mergers have been healthy by providing resources and growth opportunities to small- to medium-sized companies that would have not been possible otherwise." With regard to it being a positive trend, most respondents agreed with Plotica. In fact, three times as many respondents stated it is a healthy trend as opposed to those who believe it is not good for industry. "Every buyout and merger has victims and winners," one respondent said. "It also creates opportunities. Ultimately the industry does become more efficient, which is healthy."

It appeared, however, that respondents who work for welding equipment and consumables manufacturers rather than end users were more likely to consider it a negative trend. "The welding industry is getting smaller every year," one respondent wrote. Another said, "Who's left to buy without creating an antitrust monopoly issue?"

Langdon of Vermeer presented a case for both sides. On the positive side, Langdon said, "Larger companies have more resources for research and development. Also, mergers present a larger buying power and, in some cases, allegiances to manufacturers. Some of the buyouts that we are seeing, especially in the equipment rental industry, could be a real boon to our company." On the negative side, "less competition," he said.

While stating that "company buyouts and mergers can have very positive benefits for the industry and the consumer," Emmerson also put in a word of caution. "To use an overworked phrase," he said, "if there are no 'synergies' between a group of companies beyond the fact that they are associated with the welding industry, the risk is that the performance of small, newly acquired companies will suffer as their original owners bail out and no strong management fills the void."

Sumner voiced the opinion of several respondents when he said, "I believe that these consolidations have fostered an environment that is healthy for the industry with more focused competition between larger manufacturers. This competition is good for all of us to help move the industry forward and provide customer solutions."

Conclusion

Since time machines still exist only in the stories of H. G. Wells and other works of science fiction, no one can tell us exactly how welding will fare in the 21st century. However, the people who responded to the Welding Journal survey represent a cross section of fabricators of welded products and producers of welding equipment and related products. Together they offer a wide range of experience and knowledge. Answering the questions separately, in their respective cities, they still formed a consensus. They agree the future looks promising for welding. It remains and will continue to be a productive, cost-effective manufacturing method. However, steps must be taken to bring more skilled personnel into the industry, or changes must be made to accommodate for the lack of skilled personnel (e.g., welding automation). They also indicated the welding industry must embrace all of the modern-day technological tools to keep pace with the rest of the world.

13 Continue the list of optimistic and pessimistic scenarios for welding technology development in the future.

“projections for the future are generally optimistic…”	*“but a few gray clouds roam the horizon”*
1. Welding is here to stay and will be used more in the future. 2. The consumer welding market will	1. Designs will be more efficient to minimize the amount of welding. 2. There will be a decline in the use

continue to provide opportunities for growth. 3. …	of gas metal arc (GMAW) and gas tungsten arc welding (GTAW). 3. …

Speaking

14 Comment on the predictions. Say if you agree or disagree with each of them and why. The phrases below will help you.

Meaning	**Formal**
Agreeing	This is absolutely right. This is true. I agree with you. I suppose you may be right.
Disagreeing	I'm afraid I can't agree with you. This is not quite right. I'm not sure you are right about …
Saying you are partly agreed	I partly agree, but … I suppose so, but … I agree up to a point

APPENDIX 1. WELDING THEORY & APPLICATION DEFINITIONS

ACETONE

A flammable, volatile liquid used in acetylene cylinders to dissolve and stabilize acetylene under high pressure.

ACETYLENE

A highly combustible gas composed of carbon and hydrogen. Used as a fuel gas in the oxyacetylene welding process.

ACTUAL THROAT

See THROAT OF FILLET WELD.

AIR-ACETYLENE

A low temperature flare produced by burning acetylene with air instead of oxygen.

AIR-ARC CUTTING

An arc cutting process in which metals to be cut are melted by the heat of the carbon arc.

ALLOY

A mixture with metallic properties composed of two or more elements, of which at least one is a metal.

ALTERNATING CURRENT

An electric current that reverses its direction at regularly recurring intervals.

AMMETER

An instrument for measuring electrical current in amperes by an indicator activated by the movement of a coil in a magnetic field or by the longitudinal expansion of a wire carrying the current.

ANNEALING

A comprehensive term used to describe the heating and cooling cycle of steel in the solid state. The term annealing usually implies relatively slow cooling. In annealing, the temperature of the operation, the rate of heating and cooling, and the time the metal is held at heat depend upon the composition, shape, and size of the steel product being treated, and the purpose of the treatment. The more important purposes for which steel is annealed are as follows to remove stresses; to induce softness; to alter ductility, toughness, electric, magnetic, or other physical and mechanical properties; to change the crystalline structure; to remove gases; and to produce a definite microstructure.

ARC BLOW

The deflection of an electric arc from its normal path because of magnetic forces.

ARC BRAZING

A brazing process wherein the heat is obtained from an electric arc formed between the base metal and an electrode, or between two electrodes.

ARC CUTTING

A group of cutting processes in which the cutting of metals is accomplished by melting with the heat of an arc between the electrode and the base metal. See CARBON-ARC CUTTING, METAL-ARC CUTTING, ARC-OXYGEN CUTTING, AND AIR-ARC CUTTING.

ARC LENGTH

The distance between the tip of the electrode and the weld puddle.

ARC-OXYGEN CUTTING

An oxygen-cutting process used to sever metals by a chemical reaction of oxygen with a base metal at elevated temperatures.

ARC VOLTAGE

The voltage across the welding arc.

ARC WELDING

A group of welding processes in which fusion is obtained by heating with an electric arc or arcs, with or without the use of filler metal.

AS WELDED

The condition of weld metal, welded joints, and weldments after welding and prior to any subsequent thermal, mechanical, or chemical treatments.

ATOMIC HYDROGEN WELDING

An arc welding process in which fusion is obtained by heating with an arc maintained between two metal electrodes in an atmosphere of hydrogen. Pressure and/or filler metal may or may not be used.

AUSTENITE

The non-magnetic form of iron characterized by a face-centered cubic lattice crystal structure. It is produced by heating steel above the upper critical temperature and has a high solid solubility for carbon and alloying elements.

AXIS OF A WELD

A line through the length of a weld, perpendicular to a cross section at its center of gravity.

BACK FIRE

The momentary burning back of a flame into the tip, followed by a snap or pop, then immediate reappearance or burning out of the flame.

BACK PASS

A pass made to deposit a back weld.

BACK UP

In flash and upset welding, a locator used to transmit all or a portion of the upsetting force to the workpieces.

BACK WELD

A weld deposited at the back of a single groove weld.

BACKHAND WELDING

A welding technique in which the flame is directed towards the completed weld.

BACKING STRIP

A piece of material used to retain molten metal at the root of the weld and/or increase the thermal capacity of the joint so as to prevent excessive warping of the base metal.

BACKING WELD

A weld bead applied to the root of a single groove joint to assure complete root penetration.

BACKSTEP

A sequence in which weld bead increments are deposited in a direction opposite to the direction of progress.

BARE ELECTRODE

An arc welding electrode that has no coating other than that incidental to the drawing of the wire.

BARE METAL-ARC WELDING

An arc welding process in which fusion is obtained by heating with an unshielded arc between a bare or lightly coated electrode and the work. Pressure is not used and filler metal is obtained from the electrode.

BASE METAL

The metal to be welded or cut. In alloys, it is the metal present in the largest proportion.

BEAD WELD

A type of weld composed of one or more string or weave beads deposited on an unbroken surface.

BEADING

See STRING BEAD WELDING and WEAVE BEAD.

BEVEL ANGLE

The angle formed between the prepared edge of a member and a plane perpendicular to the surface of the member.

BLACKSMITH WELDING

See FORGE WELDING.

BLOCK BRAZING

A brazing process in which bonding is produced by the heat obtained from heated blocks applied to the parts to be joined and by a nonferrous filler metal having a melting point above 800 °F (427 °C), but below that of the base metal. The filler metal is distributed in the joint by capillary attraction.

BLOCK SEQUENCE
: A building up sequence of continuous multipass welds in which separated lengths of the weld are completely or partially built up before intervening lengths are deposited. See BUILDUP SEQUENCE.

BLOW HOLE
: see GAS POCKET.

BOND
: The junction of the welding metal and the base metal.

BOXING
: The operation of continuing a fillet weld around a corner of a member as an extension of the principal weld.

BRAZING
: A group of welding processes in which a groove, fillet, lap, or flange joint is bonded by using a nonferrous filler metal having a melting point above 800 °F (427 °C), but below that of the base metals. Filler metal is distributed in the joint by capillary attraction.

BRAZE WELDING
: A method of welding by using a filler metal that liquefies above 450°C (842 °F) and below the solid state of the base metals. Unlike brazing, in braze welding, the filler metal is not distributed in the joint by capillary action.

BRIDGING
: A welding defect caused by poor penetration. A void at the root of the weld is spanned by weld metal.

BUCKLING
: Distortion caused by the heat of a welding process.

BUILDUP SEQUENCE
: The order in which the weld beads of a multipass weld are deposited with respect to the cross section of a joint. See BLOCK SEQUENCE.

BUTT JOINT
: A joint between two workpieces in such a manner that the weld joining the parts is between the surface planes of both of the pieces joined.

BUTT WELD
: A weld in a butt joint.

BUTTER WELD
: A weld caused of one or more string or weave beads laid down on an unbroken surface to obtain desired properties or dimensions.

CAPILLARY ATTRACTION

The phenomenon by which adhesion between the molten filler metal and the base metals, together with surface tension of the molten filler metal, causes distribution of the filler metal between the properly fitted surfaces of the joint to be brazed.

CARBIDE PRECIPITATION

A condition occurring in austenitic stainless steel which contains carbon in a supersaturated solid solution. This condition is unstable. Agitation of the steel during welding causes the excess carbon in solution to precipitate. This effect is also called weld decay.

CARBON-ARC CUTTING

A process of cutting metals with the heat of an arc between a carbon electrode and the work.

CARBON-ARC WELDING

A welding process in which fusion is produced by an arc between a carbon electrode and the work. Pressure and/or filler metal and/or shielding may or may not be used.

CARBONIZING FLAME

An oxyacetylene flame in which there is an excess of acetylene. Also called excess acetylene or reducing flame.

CASCADE SEQUENCE Subsequent beads are stopped short of a previous bead, giving a cascade effect.

CASE HARDENING

A process of surface hardening involving a change in the composition of the outer layer of an iron base alloy by inward diffusion from a gas or liquid, followed by appropriate thermal treatment. Typical hardening processes are carbonizing, cyaniding, carbonitriding, and nitriding.

CHAIN INTERMITTENT FILLET WELDS

Two lines of intermittent fillet welds in a T or lap joint in which the welds in one line are approximately opposite those in the other line.

CHAMFERING

The preparation of a welding contour, other than for a square groove weld, on the edge of a joint member.

COALESCENCE

The uniting or fusing of metals upon heating.

COATED ELECTRODE

An electrode having a flux applied externally by dipping, spraying, painting, or other similar methods. Upon burning, the coat produces a gas which envelopes the arc.

COMMUTORY CONTROLLED WELDING
The making of a number of spot or projection welds in which several electrodes, in simultaneous contact with the work, progressively function under the control of an electrical commutating device.

COMPOSITE ELECTRODE
A filler metal electrode used in arc welding, consisting of more than one metal component combined mechanically. It may or may not include materials that improve the properties of the weld, or stabilize the arc.

COMPOSITE JOINT
A joint in which both a thermal and mechanical process are used to unite the base metal parts.

CONCAVITY
The maximum perpendicular distance from the face of a concave weld to a line joining the toes.

CONCURRENT HEATING
Supplemental heat applied to a structure during the course of welding.

CONE
The conical part of a gas flame next to the orifice of the tip.

CONSUMABLE INSERT
Preplaced filler metal which is completely fused into the root of the joint and becomes part of the weld.

CONVEXITY
The maximum perpendicular distance from the face of a convex fillet weld to a line joining the toes.

CORNER JOINT
A joint between two members located approximately at right angles to each other in the form of an L.

COVER GLASS
A clear glass used in goggles, hand shields, and helmets to protect the filter glass from spattering material.

COVERED ELECTRODE
A metal electrode with a covering material which stabilizes the arc and improves the properties of the welding metal. The material may be an external wrapping of paper, asbestos, and other materials or a flux covering.

CRACK
A fracture type discontinuity characterized by a sharp tip and high ratio of length and width to opening displacement.

CRATER
A depression at the termination of an arc weld.

CRITICAL TEMPERATURE

The transition temperature of a substance from one crystalline form to another.

CURRENT DENSITY

Amperes per square inch of the electrode cross sectional area.

CUTTING TIP

A gas torch tip especially adapted for cutting.

CUTTING TORCH

A device used in gas cutting for controlling the gases used for preheating and the oxygen used for cutting the metal.

CYLINDER

A portable cylindrical container used for the storage of a compressed gas.

DEFECT

A discontinuity or discontinuities which, by nature or accumulated effect (for example, total crack length), render a part or product unable to meet the minimum applicable acceptance standards or specifications. This term designates rejectability.

DEPOSITED METAL

Filler metal that has been added during a welding operation.

DEPOSITION EFFICIENCY

The ratio of the weight of deposited metal to the net weight of electrodes consumed, exclusive of stubs.

DEPTH OF FUSION

The distance from the original surface of the base metal to that point at which fusion ceases in a welding operation.

DIE

a. Resistance Welding. A member, usually shaped to the work contour, used to clamp the parts being welded and conduct the welding current.

b. Forge Welding. A device used in forge welding primarily to form the work while hot and apply the necessary pressure.

DIE WELDING

A forge welding process in which fusion is produced by heating in a furnace and by applying pressure by means of dies.

DIP BRAZING

A brazing process in which bonding is produced by heating in a molten chemical or metal bath and by using a nonferrous filler metal having a melting point above 800 °F (427 °C), but below that of the base metals. The filler metal is distributed in the joint by capillary attraction. When a metal bath is used, the bath provides the filler metal.

DIRECT CURRENT ELECTRODE NEGATIVE (DCEN)

The arrangement of direct current arc welding leads in which the work is the positive pole and the electrode is the negative pole of the welding arc.

DIRECT CURRENT ELECTRODE POSITIVE (DCEP)

The arrangement of direct current arc welding leads in which the work is the negative pole and the electrode is the positive pole of the welding arc.

DISCONTINUITY

An interruption of the typical structure of a weldment, such as lack of homogeneity in the mechanical, metallurgical, or physical characteristics of the material or weldment. A discontinuity is not necessarily a defect.

DRAG

The horizontal distance between the point of entrance and the point of exit of a cutting oxygen stream.

DUCTILITY

The property of a metal which allows it to be permanently deformed, in tension, before final rupture. Ductility is commonly evaluated by tensile testing in which the amount of elongation and the reduction of area of the broken specimen, as compared to the original test specimen, are measured and calculated.

DUTY CYCLE

The percentage of time during an arbitrary test period, usually 10 minutes, during which a power supply can be operated at its rated output without overloading.

EDGE JOINT

A joint between the edges of two or more parallel or nearly parallel members.

EDGE PREPARATION

The contour prepared on the edge of a joint member for welding.

EFFECTIVE LENGTH OF WELD

The length of weld throughout which the correctly proportioned cross section exits.

ELECTRODE

a. <u>Metal-Arc</u>. Filler metal in the form of a wire or rod, whether bare or covered, through which current is conducted between the electrode holder and the arc.

b. <u>Carbon-Arc</u>. A carbon or graphite rod through which current is conducted between the electrode holder and the arc.

c. Atomic . One of the two tungsten rods between the points of which the arc is maintained.

d. Electrolytic Oxygen-Hydrogen Generation. The conductors by which current enters and leaves the water, which is decomposed by the passage of the current.

e. Resistance Welding. The part or parts of a resistance welding machine through which the welding current and the pressure are applied directly to the work.

ELECTRODE FORCE

a. Dynamic. In spot, seam, and projection welding, the force (pounds) between the electrodes during the actual welding cycle.

b. Theoretical. In spot, seam, and projection welding, the force, neglecting friction and inertia, available at the electrodes of a resistance welding machine by virtue of the initial force application and the theoretical mechanical advantage of the system.

c. Static. In spot, seam, and projection welding, the force between the electrodes under welding conditions, but with no current flowing and no movement in the welding machine.

ELECTRODE HOLDER

A device used for mechanically holding the electrode and conduct- ing current to it.

ELECTRODE SKID

The sliding of an electrode along the surface of the work during spot, seam, or projection welding.

EMBOSSMENT

A rise or protrusion from the surface of a metal.

ETCHING

A process of preparing metallic specimens and welds for macrographic or micrographic examination.

FACE REINFORCEMENT

Reinforcement of weld at the side of the joint from which welding was done.

FACE OF WELD

The exposed surface of a weld, made by an arc or gas welding process, on the side from which welding was done.

FAYING SURFACE

That surface of a member that is in contact with another member to which it is joined.

FERRITE

The virtually pure form of iron existing below the lower critical temperature and characterized by a body-centered cubic lattice crystal structure. It is magnetic and has very slight solid solubility for carbon.

FILLER METAL

Metal to be added in making a weld.

FILLET WELD

A weld of approximately triangular cross section, as used in a lap joint, joining two surfaces at approximately right angles to each other.

FILTER GLASS

A colored glass used in goggles, helmets, and shields to exclude harmful light rays.

FLAME CUTTING

see OXYGEN CUTTING.

FLAME GOUGING

See OXYGEN GOUGING.

FLAME HARDENING

A method for hardening a steel surface by heating with a gas flame followed by a rapid quench.

FLAME SOFTENING

A method for softening steel by heating with a gas flame followed by slow cooling.

FLASH

Metal and oxide expelled from a joint made by a resistance welding process.

FLASH WELDING

A resistance welding process in which fusion is produced, simultaneously over the entire area of abutting surfaces, by the heat obtained from resistance to the flow of current between two surfaces and by the application of pressure after heating is substantially completed. Flashing is accompanied by expulsion of metal from the joint.

FLASHBACK

The burning of gases within the torch or beyond the torch in the hose, usually with a shrill, hissing sound.

FLAT POSITION

The position in which welding is performed from the upper side of the joint and the face of the weld is approximately horizontal.

FILM BRAZING

A process in which bonding is produced by heating with a molten nonferrous filler metal poured over the joint until the brazing temperature is attained. The filler metal is distributed in the joint by capillary attraction. See BRAZING.

FLOW WELDING

A process in which fusion is produced by heating with molten filler metal poured over the surfaces to be welded until the welding temperature is attained and the required filler metal has been added. The filler metal is not distributed in the joint by capillary attraction.

FLUX

A cleaning agent used to dissolve oxides, release trapped gases and slag, and to cleanse metals for welding, soldering, and brazing.

FOREHAND WELDING

A gas welding technique in which the flare is directed against the base metal ahead of the completed weld.

FORGE WELDING

A group of welding processes in which fusion is produced by heating in a forge or furnace and applying pressure or blows.

FREE BEND TEST

A method of testing weld specimens without the use of a guide.

FULL FILLET WELD

A fillet weld whose size is equal to the thickness of the thinner member joined.

FURNACE BRAZING

A process in which bonding is produced by the furnace heat and a nonferrous filler metal having a melting point above 800 °F (427 °C), but below that of the base metals. The filler metal is distributed in the joint by capillary attraction.

FUSION

A thorough and complete mixing between the two edges of the base metal to be joined or between the base metal and the filler metal added during welding.

FUSION ZONE (FILLER PENETRATION)

The area of base metal melted as determined on the cross section of a weld.

GAS CARBON-ARC WELDING

An arc welding process in which fusion is produced by heating with an electric arc between a carbon electrode and the work. Shielding is obtained from an inert gas such as helium or argon. Pressure and/or filler metal may or may not be used.

GAS METAL-ARC (MIG) WELDING (GMAW)

An arc welding process in which fusion is produced by heating with an electric arc between a metal electrode and the work. Shielding is obtained from an inert gas such as helium or argon. Pressure and/or filler metal may or my not be used.

GAS POCKET

A weld cavity caused by the trapping of gases released by the metal when cooling.

GAS TUNGSTEN-ARC (TIG) WELDING (GTAW)

An arc welding process in which fusion is produced by heating with an electric arc between a tungsten electrode and the work while an inert gas forms around the weld area to prevent oxidation. No flux is used.

GAS WELDING

A process in which the welding heat is obtained from a gas flame.

GLOBULAR TRANSFER (ARC WELDING)

A type of metal transfer in which molten filler metal is transferred across the arc in large droplets.

GOGGLES

A device with colored lenses which protect the eyes from harmful radiation during welding and cutting operations.

GROOVE

The opening provided between two members to be joined by a groove weld.

GROOVE ANGLE

The total included angle of the groove between parts to be joined by a groove weld.

GROOVE FACE

That surface of a member included in the groove.

GROOVE RADIUS

The radius of a J or U groove.

GROOVE WELD

A weld made by depositing filler metal in a groove between two members to be joined.

GROUND CONNECTION

The connection of the work lead to the work.

GROUND LEAD

See WORK LEAD.

GUIDED BEND TEST

A bending test in which the test specimen is bent to a definite shape by means of a jig.

HAMMER WELDING

A forge welding process.

HAND SHIELD

A device used in arc welding to protect the face and neck. It is equipped with a filter glass lens and is designed to be held by hand.

HARD FACING

A particular form of surfacing in which a coating or cladding is applied to a surface for the main purpose of reducing wear or loss of material by abrasion, impact, erosion, galling, and cavitations.

HARD SURFACING

The application of a hard, wear-resistant alloy to the surface of a softer metal.

HARDENING

a. The heating and quenching of certain iron-base alloys from a temperature above the critical temperature range for the purpose of producing a hardness superior to that obtained when the alloy is not quenched. This term is usually restricted to the formation of martensite.

b. Any process of increasing the hardness of metal by suitable treatment, usually involving heating and cooling.

HEAT AFFECTED ZONE

That portion of the base metal whose structure or properties have been changed by the heat of welding or cutting.

HEAT TIME

The duration of each current impulse in pulse welding.

HEAT TREATMENT

An operation or combination of operations involving the heating and cooling of a metal or an alloy in the solid state for the purpose of obtaining certain desirable conditions or properties. Heating and cooling for the sole purpose of mechanical working are excluded from the meaning of the definition.

HEATING GATE

The opening in a thermit mold through which the parts to be welded are preheated.

HELMET

A device used in arc welding to protect the face and neck. It is equipped with a filter glass and is designed to be worn on the head.

HOLD TIME

The time that pressure is maintained at the electrodes after the welding current has stopped.

HORIZONTAL WELD

A bead or butt welding process with its linear direction horizontal or inclined at an angle less than 45 degrees to the horizontal, and the parts welded being vertically or approximately vertically disposed.

HORN

The electrode holding arm of a resistance spot welding machine.

HORN SPACING

In a resistance welding machine, the unobstructed work clearance between horns or platens at right angles to the throat depth. This distance is measured with the horns parallel and horizontal at the end of the downstroke.

HOT SHORT

A condition which occurs when a metal is heated to that point, prior to melting, where all strength is lost but the shape is still maintained.

HYDROGEN BRAZING

A method of furnace brazing in a hydrogen atmosphere.

HYDROMATIC WELDING

See PRESSURE CONTROLLED WELDING.

HYGROSCOPIC

Readily absorbing and retaining moisture.

IMPACT TEST

A test in which one or more blows are suddenly applied to a specimen. The results are usually expressed in terms of energy absorbed or number of blows of a given intensity required to break the specimen.

IMPREGNATED-TAPE METAL-ARC WELDING

An arc welding process in which fusion is produced by heating with an electric arc between a metal electrode and the work. Shielding is obtained from decomposition of impregnated tape wrapped around the electrode as it is fed to the arc. Pressure is not used, and filler metal is obtained from the electrode.

INDUCTION BRAZING

A process in which bonding is produced by the heat obtained from the resistance of the work to the flow of induced electric current and by using a nonferrous filler metal having a melting point above 800 °F (427 °C), but below that of the base metals. The filler metal is distributed in the joint by capillary attraction.

INDUCTION WELDING

A process in which fusion is produced by heat obtained from resistance of the work to the flow of induced electric current, with or without the application of pressure.

INERT GAS

A gas which does not normally combine chemically with the base metal or filler metal.

INTERPASS TEMPERATURE

In a multipass weld, the lowest temperature of the deposited weld meal before the next pass is started.

JOINT

The portion of a structure in which separate base metal parts are joined.

JOINT PENETRATION

The maximum depth a groove weld extends from its face into a joint, exclusive of reinforcement.

KERF

The space from which metal has been removed by a cutting process.

LAP JOINT

A joint between two overlapping members.

LAYER

A stratum of weld metal, consisting of one or more weld beads.

LEG OF A FILLET WELD

The distance from the root of the joint to the toe of the fillet weld.

LIQUIDUS

The lowest temperature at which a metal or an alloy is completely liquid.

LOCAL PREHEATING

Preheating a specific portion of a structure.

LOCAL STRESS RELIEVING

Stress relieving heat treatment of a specific portion of a structure.

MANIFOLD

A multiple header for connecting several cylinders to one or more torch supply lines.

MARTENSITE

Martensite is a microconstituent or structure in quenched steel characterized by an acicular or needle-like pattern on the surface of polish. It has the maximum hardness of any of the structures resulting from the decomposition products of austenite.

MASH SEAM WELDING

A seam weld made in a lap joint in which the thickness at the lap is reduced to approximately the thickness of one of the lapped joints by applying pressure while the metal is in a plastic state.

MELTING POINT

The temperature at which a metal begins to liquefy.

MELTING RANGE

The temperature range between solidus and liquidus.

MELTING RATE

The weight or length of electrode melted in a unit of time.

METAL-ARC CUTTING

The process of cutting metals by melting with the heat of the metal arc.

METAL-ARC WELDING

An arc welding process in which a metal electrode is held so that the heat of the arc fuses both the electrode and the work to form a weld.

METALLIZING

A method of overlay or metal bonding to repair worn parts.

MIXING CHAMBER

That part of a welding or cutting torch in which the gases are mixed for combustion.

MULTI-IMPULSE WELDING

The making of spot, projection, and upset welds by more than one impulse of current. When alternating current is used each impulse may consist of a fraction of a cycle or a number of cycles.

NEUTRAL FLAME

A gas flame in which the oxygen and acetylene volumes are balanced and both gases are completely burned.

NICK BREAK TEST

A method for testing the soundness of welds by nicking each end of the weld, then giving the test specimen a sharp hammer blow to break the weld from nick to nick. Visual inspection will show any weld defects.

NONFERROUS

Metals which contain no iron. Aluminum, brass, bronze, copper, lead, nickel, and titanium are nonferrous.

NORMALIZING

Heating iron-base alloys to approximately 100 °F (38 °C) above the critical temperature range followed by cooling to below that range in still air at ordinary temperature.

NUGGET

The fused metal zone of a resistance weld.

OPEN CIRCUIT VOLTAGE

The voltage between the terminals of the welding source when no current is flowing in the welding circuit.

OVERHEAD POSITION

The position in which welding is performed from the underside of a joint and the face of the weld is approximately horizontal.

OVERLAP

The protrusion of weld metal beyond the bond at the toe of the weld.

OXIDIZING FLAME

An oxyacetylene flame in which there is an excess of oxygen. The unburned excess tends to oxidize the weld metal.

OXYACETYLENE CUTTING

An oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained from the combustion of acetylene with oxygen.

OXYACETYLENE WELDING

A welding process in which the required temperature is attained by flames obtained from the combustion of acetylene with oxygen.

OXY-ARC CUTTING

An oxygen cutting process in which the necessary cutting temperature is maintained by means of an arc between an electrode and the base metal.

OXY-CITY GAS CUTTING

An oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained from the combustion of city gas with oxygen.

OXYGEN CUTTING

A process of cutting ferrous metals by means of the chemical action of oxygen on elements in the base metal at elevated temperatures.

OXYGEN GOUGING

An application of oxygen cutting in which a chamfer or groove is formed.

OXY-HYDROGEN CUTTING

An oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained from the combustion of city gas with oxygen.

OXY-HYDROGEN WELDING

A gas welding process in which the required welding temperature is attained by flames obtained from the combustion of hydrogen with oxygen.

OXY-NATURAL GAS CUTTING

An oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained by the combustion of natural gas with oxygen.

OXY-PROPANE CUTTING

An oxygen cutting process in which the necessary cutting temperature is maintained by flames obtained from the combustion of propane with oxygen.

PASS

The weld metal deposited in one general progression along the axis of the weld.

PEENING

The mechanical working of metals by means of hammer blows. Peening tends to stretch the surface of the cold metal, thereby relieving contraction stresses.

PENETRANT INSPECTION

a. Fluorescent. A water washable penetrant with high fluorescence and low surface tension. It is drawn into small surface openings by capillary action. When exposed to black light, the dye will fluoresce.

b. Dye. A process which involves the use of three noncorrosive liquids. First, the surface cleaner solution is used. Then the penetrant is applied and allowed to stand at least 5 minutes. After standing, the penetrant is removed with the leaner solution and the developer is applied. The dye penetrant, which has remained in the surface discontinuity, will be drawn to the surface by the developer resulting in bright red indications.

PERCUSSIVE WELDING

A resistance welding process in which a discharge of electrical energy and the application of high pressure occurs simultaneously, or with the electrical discharge occurring slightly before the application of pressure.

PERLITE

Perlite is the lamellar aggregate of ferrite and iron carbide resulting from the direct transformation of austenite at the lower critical point.

PITCH

Center to center spacing of welds.

PLUG WELD

A weld is made in a hole in one member of a lap joint, joining that member to that portion of the surface of the other member which is exposed through the hole. The walls of the hole may or may not be parallel, and the hole may be partially or completely filled with the weld metal.

POKE WELDING

A spot welding process in which pressure is applied manually to one electrode. The other electrode is clamped to any part of the metal much in the same manner that arc welding is grounded.

POROSITY

The presence of gas pockets or inclusions in welding.

POSITIONS OF WELDING

All welding is accomplished in one of four positions flat, horizontal, overhead, and vertical. The limiting angles of the various positions depend somewhat as to whether the weld is a fillet or groove weld.

POSTHEATING

The application of heat to an assembly after a welding, brazing, soldering, thermal spraying, or cutting operation.

POSTWELD INTERVAL

In resistance welding, the heat time between the end of weld time, or weld interval, and the start of hold time. During this interval, the weld is subjected to mechanical and heat treatment.

PREHEATING

The application of heat to a base metal prior to a welding or cutting operation.

PRESSURE CONTROLLED WELDING

The making of a number of spot or projection welds in which several electrodes function progressively under the control of a pressure sequencing device.

PRESSURE WELDING

Any welding process or method in which pressure is used to complete the weld.

PREWELD INTERVAL

In spot, projection, and upset welding, the time between the end of squeeze time and the start of weld time or weld interval during which the material is preheated. In flash welding, it is the time during which the material is preheated.

PROCEDURE QUALIFICATION

The demonstration that welds made by a specific procedure can meet prescribed standards.

PROJECTION WELDING

A resistance welding process between two or more surfaces or between the ends of one member and the surface of another. The welds are localized at predetermined points or projections.

PULSATION WELDING

A spot, projection, or seam welding process in which the welding current is interrupted one or more times without the release of pressure or change of location of electrodes.

PUSH WELDING

The making of a spot or projection weld in which the force is aping current is interrupted one or more times without the release of pressure or change of location of electrodes.

PUSH WELDING

The making of a spot or projection weld in which the force is applied manually to one electrode and the work or a backing bar takes the place of the other electrode.

QUENCHING

The sudden cooling of heated metal with oil, water, or compressed air.

REACTION STRESS

The residual stress which could not otherwise exist if the members or parts being welded were isolated as free bodies without connection to other parts of the structure.

REDUCING FLAME

See CARBONIZING FLAME.

REGULATOR

A device used to reduce cylinder pressure to a suitable torch working pressure.

REINFORCED WELD

The weld metal built up above the surface of the two abutting sheets or plates in excess of that required for the size of the weld specified.

RESIDUAL STRESS

Stress remaining in a structure or member as a result of thermal and/or mechanical treatment.

RESISTANCE BRAZING

A brazing process in which bonding is produced by the heat obtained from resistance to the flow of electric current in a circuit of which the workpiece is a part, and by using a nonferrous filler metal having a melting point above 800 °F (427 °C), but below that of the base metals. The filler metal is distributed in the joint by capillary attraction.

RESISTANCE BUTT WELDING

A group of resistance welding processes in which the weld occurs simultaneously over the entire contact area of the parts being joined.

RESISTANCE WELDING

A group of welding processes in which fusion is produced by heat obtained from resistance to the flow of electric current in a circuit of which the workpiece is a part and by the application of pressure.

REVERSE POLARITY

The arrangement of direct current arc welding leads in which the work is the negative pole and the electrode is the positive pole of the welding arc.

ROCKWELL HARDNESS TEST

In this test a machine measures hardness by determining the depth of penetration of a penetrator into the specimen under certain arbitrary fixed conditions of test. The penetrator may be either a steel ball or a diamond spherocone.

ROOT

See ROOT OF JOINT and ROOT OF WELD.

ROOT CRACK

A crack in the weld or base metal which occurs at the root of a weld.

ROOT EDGE

The edge of a part to be welded which is adjacent to the root.

ROOT FACE

The portion of the prepared edge of a member to be joined by a groove weld which is not beveled or grooved.

ROOT OF JOINT

That portion of a joint to be welded where the members approach closest to each other. In cross section, the root of a joint may be a point, a line, or an area.

ROOT OF WELD

The points, as shown in cross section, at which the bottom of the weld intersects the base metal surfaces.

ROOT OPENING

The separation between the members to be joined at the root of the joint.

ROOT PENETRATION

The depth a groove weld extends into the root of a joint measured on the centerline of the root cross section.

SCARF

The chamfered surface of a joint.

SCARFING

A process for removing defects and checks which develop in the rolling of steel billets by the use of a low velocity oxygen deseaming torch.

SEAL WELD

A weld used primarily to obtain tightness and to prevent leakage.

SEAM WELDING

Welding a lengthwise seam in sheet metal either by abutting or overlapping joints.

SELECTIVE BLOCK SEQUENCE

A block sequence in which successive blocks are completed in a certain order selected to create a predetermined stress pattern.

SERIES WELDING

A resistance welding process in which two or more welds are made simultaneously by a single welding transformer with the total current passing through each weld.

SHEET SEPARATION

In spot, seam, and projection welding, the gap surrounding the weld between faying surfaces, after the joint has been welded.

SHIELDED WELDING

An arc welding process in which protection from the atmosphere is obtained through use of a flux, decomposition of the electrode covering, or an inert gas.

SHOULDER

See ROOT FACE.

SHRINKAGE STRESS

See RESIDUAL STRESS.

SINGLE IMPULSE WELDING

The making of spot, projection, and upset welds by a single impulse of current. When alternating current is used, an impulse may consist of a fraction of a cycle or a number of cycles.

SIZE OF WELD

a. <u>Groove weld</u>. The joint penetration (depth of chamfering plus the root penetration when specified).

b. <u>Equal leg fillet welds</u>. The leg length of the largest isosceles right triangle which can be inscribed within the fillet weld cross section.

c. <u>Unequal leg fillet welds</u>. The leg length of the largest right triangle which can be inscribed within the fillet weld cross section.

d. <u>Flange weld</u>. The weld metal thickness measured at the root of the weld.

SKIP SEQUENCE

See WANDERING SEQUENCE.

SLAG INCLUSION

Non-metallic solid material entrapped in the weld metal or between the weld metal and the base metal.

SLOT WELD

A weld made in an elongated hole in one member of a lap or tee joint joining that member to that portion of the surface of the other member which is exposed through the hole. The hole may be open at one end and may be partially or completely filled with weld metal. (A fillet welded slot should not be construed as conforming to this definition.)

SLUGGING

Adding a separate piece or pieces of material in a joint before or during welding with a resultant welded joint that does not comply with design drawing or specification requirements.

SOLDERING

A group of welding processes which produce coalescence of materials by heating them to suitable temperature and by using a filler metal having a liquidus not exceeding 450 °C (842 °F) and below the solidus of the base materials. The filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

SOLIDUS

The highest temperature at which a metal or alloy is completely solid.

SPACER STRIP

A metal strip or bar inserted in the root of a joint prepared for a groove weld to serve as a backing and to maintain the root opening during welding.

SPALL

Small chips or fragments which are sometimes given off by electrodes during the welding operation. This problem is especially common with heavy coated electrodes.

SPATTER

The metal particles expelled during arc and gas welding which do not form a part of the weld.

SPOT WELDING

A resistance welding process in which fusion is produced by the heat obtained from the resistance to the flow of electric current through the workpieces held together under pressure by electrodes. The size and shape of the individually formed welds are limited by the size and contour of the electrodes.

SPRAY TRANSFER

A type of metal transfer in which molten filler metal is propelled axially across the arc in small droplets.

STAGGERED INTERMITTENT FILLET WELD

Two lines of intermittent welding on a joint, such as a tee joint, wherein the fillet increments in one line are staggered with respect to those in the other line.

STORED ENERGY WELDING

The making of a weld with electrical energy accumulated electrostatically, electromagnetically, or electrochemically at a relatively low rate and made available at the required welding rate.

STRAIGHT POLARITY

The arrangement of direct current arc welding leads in which the work is the positive pole and the electrode is the negative pole of the welding arc.

STRESS RELIEVING

A process of reducing internal residual stresses in a metal object by heating to a suitable temperature and holding for a proper time at that temperature. This treatment may he applied to relieve stresses induced by casting, quenching, normalizing, machining, cold working, or welding.

STRING BEAD WELDING

A method of metal arc welding on pieces 3/4 in. (19 mm) thick or heavier in which the weld metal is deposited in layers composed of strings of beads applied directly to the face of the bevel.

STUD WELDING

An arc welding process in which fusion is produced by heating with an electric arc drawn between a metal stud, or similar part, and the other workpiece, until the surfaces to be joined are properly heated. They are brought together under pressure.

SUBMERGED ARC WELDING

An arc welding process in which fusion is produced by heating with an electric arc or arcs between a bare metal electrode or electrodes and the work. The welding is shield by a blanket of granular, fusible material on the work. Pressure is not used. Filler metal is obtained from the electrode, and sometimes from a supplementary welding rod.

SURFACING

The deposition of filler metal on a metal surface to obtain desired properties or dimensions.

TACK WELD

A weld made to hold parts of a weldment in proper alignment until the final welds are made.

TEE JOINT

A joint between two members located approximately at right angles to each other in the form of a T.

TEMPER COLORS

The colors which appear on the surface of steel heated at low temperature in an oxidizing atmosphere.

TEMPERING

Reheating hardened steel to some temperature below the lower critical temperature, followed by a desired rate of cooling. The object of tempering a steel that has been hardened by quenching is to release stresses set up, to restore some of its ductility, and to develop toughness through the regulation or readjustment of the embrittled structural constituents of the metal. The temperature conditions for tempering may be selected for a given composition of steel to obtain almost any desired combination of properties.

TENSILE STRENGTH

The maximum load per unit of original cross-sectional area sustained by a material during the tension test.

TENSION TEST

A test in which a specimen is broken by applying an increasing load to the two ends. During the test, the elastic properties and the ultimate tensile strength of the material are determined. After rupture, the broken specimen may be measured for elongation and reduction of area.

THERMIT CRUCIBLE

The vessel in which the thermit reaction takes place.

THERMIT MIXTURE

A mixture of metal oxide and finely divided aluminum with the addition of alloying metals as required.

THERMIT MOLD

A mold formed around the parts to be welded to receive the molten metal.

THERMIT REACTION

The chemical reaction between metal oxide and aluminum which produces superheated molten metal and aluminum oxide slag.

THERMIT WELDING

A group of welding processes in which fusion is produced by heating with superheated liquid metal and slag resulting from a chemical reaction between a metal oxide and aluminum, with or without the application of pressure. Filler metal, when used, is obtained from the liquid metal.

THROAT DEPTH

In a resistance welding machine, the distance from the centerline of the electrodes or platens to the nearest point of interference for flatwork or sheets. In a seam welding machine with a universal head, the throat depth is measured with the machine arranged for transverse welding.

THROAT OF FILLET WELD

a. <u>Theoretical</u>. The distance from the beginning of the root of the joint perpendicular to the hypotenuse of the largest right triangle that can be inscribed within the fillet-weld cross section.

b. <u>Actual</u>. The distance from the root of the fillet weld to the center of its face.

TOE CRACK

A crack in the base metal occurring at the toe of the weld.

TOE OF THE WELD

The junction between the face of the weld and the base metal.

TORCH

See CUTTING TORCH or WELDING TORCH.

TORCH BRAZING

A brazing process in which bonding is produced by heating with a gas flame and by using a nonferrous filler metal having a melting point above 800 °F (427 °C), but below that of the base metal. The filler metal is distributed in the joint of capillary attraction.

TRANSVERSE SEAM WELDING

The making of a seam weld in a direction essentially at right angles to the throat depth of a seam welding machine.

TUNGSTEN ELECTRODE

A non-filler metal electrode used in arc welding or cutting, made principally of tungsten.

UNDERBEAD CRACK

A crack in the heat affected zone not extending to the surface of the base metal.

UNDERCUT

A groove melted into the base metal adjacent to the toe or root of a weld and left unfilled by weld metal.

UNDERCUTTING

An undesirable crater at the edge of the weld caused by poor weaving technique or excessive welding speed.

UPSET

A localized increase in volume in the region of a weld, resulting from the application of pressure.

UPSET WELDING

A resistance welding process in which fusion is produced simultaneously over the entire area of abutting surfaces, or progressively along a joint, by the heat obtained from resistance to the flow of electric current through the area of contact of those surfaces. Pressure is applied before heating is started and is maintained throughout the heating period.

UPSETTING FORCE

The force exerted at the welding surfaces in flash or upset welding.

VERTICAL POSITION

The position of welding in which the axis of the weld is approximately vertical. In pipe welding, the pipe is in a vertical position and the welding is done in a horizontal position.

WANDERING BLOCK SEQUENCE

A block welding sequence in which successive weld blocks are completed at random after several starting blocks have been completed.

WANDERING SEQUENCE

A longitudinal sequence in which the weld bead increments are deposited at random.

WAX PATTERN

Wax molded around the parts to be welded by a thermit welding process to the form desired for the completed weld.

WEAVE BEAD

A type of weld bead made with transverse oscillation.

WEAVING

A technique of depositing weld metal in which the electrode is oscillated. It is usually accomplished by a semicircular motion of the arc to the right and left of the direction of welding. Weaving serves to increase the width of the deposit, decreases overlap, and assists in slag formation.

WELD

A localized fusion of metals produced by heating to suitable temperatures. Pressure and/or filler metal may or may not be used. The filler material has a melting point approximately the same or below that of the base metals, but always above 800 °F (427 °C).

WELD BEAD

A weld deposit resulting from a pass.

WELD GAUGE

A device designed for checking the shape and size of welds.

WELD METAL

That portion of a weld that has been melted during welding.

WELD SYMBOL

A picture used to indicate the desired type of weld.

WELDABILITY

The capacity of a material to form a strong bond of adherence under pressure or when solidifying from a liquid.

WELDER CERTIFICATION

Certification in writing that a welder has produced welds meeting prescribed standards.

WELDER PERFORMANCE QUALIFICATION

The demonstration of a welder's ability to produce welds meeting prescribed standards.

WELDING LEADS

a. Electrode lead. The electrical conductor between the source of the arc welding current and the electrode holder.

b. Work lead. The electrical conductor between the source of the arc welding current and the workpiece.

WELDING PRESSURE

The pressure exerted during the welding operation on the parts being welded.

WELDING PROCEDURE

The detailed methods and practices including all joint welding procedures involved in the production of a weldment.

WELDING ROD

Filler metal in wire or rod form, used in gas welding and brazing processes and in those arc welding processes in which the electrode does not provide the filler metal.

WELDING SYMBOL

The assembled symbol consists of the following eight elements, or such of these as are necessary reference line, arrow, basic weld symbols, dimension and other data, supplementary symbols, finish symbols, tail, specification, process, or other references.

WELDING TECHNIQUE

The details of a manual, machine, or semiautomatic welding operation which, within the limitations of the prescribed joint welding procedure, are controlled by the welder or welding operator.

WELDING TIP

The tip of a gas torch especially adapted to welding.

WELDING TORCH

A device used in gas welding and torch brazing for mixing and controlling the flow of gases.

WELDING TRANSFORMER

A device for providing current of the desired voltage.

WELDMENT

An assembly whose component parts are formed by welding.

WIRE FEED SPEED

The rate of speed in mm/sec or in./min at which a filler metal is consumed in arc welding or thermal spraying.

WORK LEAD

The electric conductor (cable) between the source of arc welding current and the workpiece.

YIELD POINT

The yield point is the load per unit area value at which a marked increase in deformation of the specimen occurs with little or no increase of load; in other words, the yield point is the stress at which a marked increase in strain occurs with little or no increase in stress.

APPENDIX2. КЛАССИФИКАЦИЯ ВИДОВ И СПОСОБОВ СВАРКИ

Таблица 1

Классификация сварки металлов по ГОСТ 19521-74

Класс сварки	Определение	Вид сварки
Термический	виды сварки, осуществляемы плавлением с использованием тепловой энергии	дуговая, электрошлаковая, электронно-лучевая, плазменно-лучевая, ионно-лучевая, тлеющим разрядом, световая, индукционная, газовая, термитная, литейная.
Термомеханический	виды сварки, осуществляемые с использованием тепловой энергии и давления	контактная, диффузионная, индукционно-прессовая, газопрессовая, термокомпрессионная, дугопрессовая, шлакопрессовая, термитно-прессовая, печная
Механический	виды сварки, осуществляе мые с использованием ме ханической энергии и дав ления	холодная, взрывом, ультразвуковая, трением, магнитно-импульсная.

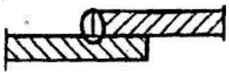
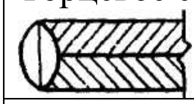
Таблица 2.

Термины и определение сварочных материалов по ГОСТ 2601-84

Термин	Определение
Сварочная проволока	проволока для использования в качестве плавящегося электрода либо присадочного металла при сварке плавлением
Электродная проволока	сварочная проволока для использования в качестве плавящегося электрода
Присадочная проволока	сварочная проволока, используемая как присадочный металл и не являющаяся электродом
Самозащитная проволока	электродная проволока, содержащая вещества, которые защищают расплавленный металл от вредного воздействия воздуха при сварке
Порошковая проволока	сварочная проволока, состоящая из металлической оболочки, заполненной порошкообразными веществами
Неплавящийся электрод для дуговой сварки	деталь из электропроводного материала, включаемая в цепь сварочного тока для подвода его к сварочной дуге и не расплавляющаяся при сварке
Плавящийся электрод для дуговой сварки	металлический электрод, включаемый в цепь сварочного тока для подвода его к сварочной дуге, расплавляющийся при сварке и служащий присадочным металлом
Покрытый электрод	плавящийся электрод для дуговой сварки, имеющий на поверхности покрытие, адгезионно связанное с металлом электрода
Покрытие электрода	смесь веществ, нанесенная на электрод для усиления ионизации, защиты от вредного воздействия среды, металлургической обработки сварочной ванны

Таблица 3.

Сварные соединения и швы

Сварное соединение	неразъемное соединение, выполненное сваркой
Стыковое соединение 	двух элементов, примыкающих друг к другу торцевыми поверхностями
Угловое соединение 	двух элементов, расположенных под углом и сваренных в месте примыкания их краев
Нахлесточное соединение 	в котором сваренные элементы расположены параллельно и частично перекрывают друг друга
Тавровое соединение 	в котором торец одного элемента примыкает под углом и приварен к боковой поверхности другого элемента
Торцевое соединение 	в котором боковые поверхности сваренных элементов примыкают друг к другу
Сварная конструкция	металлическая конструкция, изготовленная сваркой отдельных деталей
Сварной узел	часть конструкции, в которой сварены примыкающие друг к другу элементы
Сварной шов	участок сварного соединения, образовавшийся в результате кристаллизации расплавленного металла или пластической деформации при сварке давлением или сочетания кристаллизации и деформации
Проход при сварке	однократное перемещение в одном направлении источника теплоты при сварке и (или) наплавке
Основной металл	металл подвергающихся сварке соединяемых частей
Глубина проплавления	наибольшая глубина расплавления основного металла в сечении шва или наплавленного валика
Сварочная ванна	часть металла свариваемого шва, находящаяся при сварке плавлением в жидком состоянии

Окончание таблицы 3

Присадочный металл	металл для введения в сварочную ванну в дополнение к расплавленному основному металлу
Наплавленный металл	переплавленный присадочный металл, введенный в сварочную ванну или наплавленный на основной металл
Металл шва	сплав, образованный расплавленным основным и наплавленным металлами или только переплавленным основным металлом
Угар при сварке	потери металла на испарение и окисление при сварке
Свариваемость	металлический материал считается поддающимся сварке до установленной степени при данных процессах и для данной цели, когда сваркой достигается металлическая целостность при соответствующем технологическом процессе, чтобы свариваемые детали отвечали техническим требованиям как в отношении их собственных качеств, так и в отношении их влияния на конструкцию,которую они образуют
Сварочный флюс	материал, используемый при сварке для химической очистки соединяемых поверхностей и улучшения качества шва
Флюс для дуговой сварки	сварочный флюс, защищающий дугу и сварочную ванну от вредного воздействия окружающей среды

APPENDIX 3 АННОТИРОВАНИЕ И РЕФЕРИРОВАНИЕ

РЕФЕРИРОВАНИЕ

Реферирование представляет собой интеллектуальный творческий процесс, включающий осмысление, аналитико-синтетическое преобразование информации и создание нового документа – реферата, обладающего специфической языково-стилистической формой.

Реферат (Abstract) – это семантически адекватное изложение основного содержания первичного документа, отличающееся экономной знаковой оформленностью постоянством лингвистических и структурных характеристик и предназначенное для выполнения разнообразных информационно-коммуникативных функций в системе научной коммуникации.

Рефератом называется текст, передающий основную информацию подлинника в свернутом виде и составленный в результате ее смысловой переработки.

Особенности реферирования иностранных источников

Начиная работу над рефератом, переводчик должен, прежде всего, правильно выбрать вид будущего реферата и наиболее целесообразный способ охвата первоисточника.

Большое значение имеет информативность реферативных переводов. Нельзя допустить, чтобы реферат был подменен развернутой аннотацией, как это часто происходит при реферировании иностранных источников. Необходимо передать не только то, о чем написана работа, но и сущность основных идей оригинала, содержащихся в нем методов, результатов, рекомендаций и предложений. Поэтому переводчик должен быть хорошим специалистом в соответствующей области знания и уметь выявлять наиболее информативные элементы текста.

Процесс работы над текстом первоисточника складывается из нескольких этапов

1. **Ознакомительное** (ориентирующее) **чтение,** в результате которого решается вопрос о целесообразности реферирования иностранного материала. На этом этапе переводчик просматривает заглавие, введение, оглавление, выводы, резюме. Затем он бегло читает текст и определяет научно-практическую значимость и информационную новизну источника. Ключевые слова, содержащиеся в заглавии, введении, рубриках оглавления, выводах создают содержательную установку, активизирующую в дальнейшем процесс осмысления текста.

2. **Анализ вида первоисточника и выбор аспектной схемы изложения** материала в будущем реферативном тексте (общий план изложения, план изложения отраслевой методики реферирования и т.д.).

3. **Изучающее чтение текста.** Переводчик в данном случае не делает полного письменного перевода текста. Мысленное декодирование иноязычного текста происходит под влиянием установки на реферативный анализ. Необходимость выделения аспектов, обозначенных в плане изложения, активизирует мыслительную деятельность референта и придает ей поисковый характер.

5. **Разбивка текста на «аспектные блоки»** (разметка текста с помощью удобных для референта-переводчика обозначений).

6. **Конструирование** (синтез) новых высказываний на родном языке, в краткой лаконичной форме передающих основное смысловое содержание по каждому аспекту (Textrproduktion).

7. **Запись фрагментов перевода**, полученных в результате вышеописанных преобразований, в последовательности, заданной планом изложения.

8. **Критическое сравнение текстов** реферата и первоисточника с позиции потребителя и внесение в случае необходимости изменений и дополнений в текст реферата.

9**. Оформление и редактирование реферата**, когда переводчик должен придерживаться наиболее распространенной структуры, состоящей из трех элементов:

- заголовочной части (библиографическое описание первоисточника);
- собственно реферативной части, передающей основное смысловое содержание первоисточника;
- справочного аппарата (индекс, рубрикационный шифр, информация о таблицах, чертежах, графиках, иллюстрациях и т.д., примечания переводчика, фамилия переводчика или название организации, сделавшей перевод).

Таким образом, при реферировании речь идет, прежде всего, о сплошном чтении первоисточника, касается ли это использования текстовых частей документа или смысловой интерпретации текста. Главное это выбор информации, относящейся к основным элементам содержания документа, и наиболее компактное ее представление. Кроме того, в процессе реферирования происходит исключение второстепенных, малосущественных сведений, не относящихся к объекту исследования и его основным характеристикам.

АННОТИРОВАНИЕ

Аннотация (Summary) – это предельно сжатая характеристика материала, заключающаяся в информации о затронутых в источниках вопросах.

Аннотация включает характеристику основной темы, проблемы объекта, цели работы и ее результаты. В аннотации указывают, что нового несет в себе данный документ в сравнении с другими, родственными по тематике и целевому назначению.

Виды аннотаций

Существуют различные виды аннотаций в зависимости от назначения аннотации или от вида документа, на который составляется аннотация.

С точки зрения *объема* аннотации подразделяются на краткие и развернутые (или подробные).

Краткая аннотация, как правило, характеризует документ в определенном аспекте – уточнение тематического содержания, расшифровка или пополнение заглавия, оценка уровня материала и так далее.

Развернутая аннотация часто представляет собой перечисление рубрик первичного документа. Она составляется в тех случаях, когда документ представляет значительный научный интерес, а также при описании многоаспектных документов (учебники, справочники, сборники и т.д.).

С точки зрения *метода анализа и оценки документа* аннотации можно разделить на **описательные** (или справочные) и **рекомендательные** (в том числе и критические).

Описательная аннотация дает общее представление о документе, в то время как рекомендательная аннотация характеризует тематику и содержание документа под определенным углом зрения.

В информационной сфере наибольшее применение находит описательная аннотация.

В зависимости от *тематического охвата* содержания документа аннотации делятся на **общие** и **специализированные**.

Общие аннотации характеризуют весь документ в целом, они не ориентированы на определенный круг потребителей.

В специализированных аннотациях находят отражения только те части, те аспекты содержания документа, которые интересуют потребителей данной информационной системы (данного круга читателей).

В информационной практике используется, как правило, специализированная аннотация, рассчитанная на информирование специалиста определенной отрасли научной или практической деятельности. Такой вид аннотации целесообразен и при работе с литературой в учебном процессе – при подготовке рефератов, докладов и других научных работ студентами.

Этапы аннотирования

Аннотации всегда предпосылаются библиографические данные первоисточника.

В аннотациях обычно содержатся следующие данные:

1) предметная рубрика;

2) тема;

3) сжатая характеристика материала;

4) выходные данные (автор и заглавие статьи, название и номер периодического издания, где помещена статья, место и время издания).

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