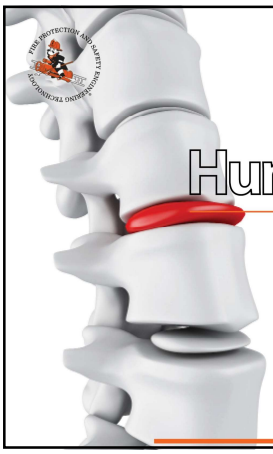


Human Factors
in Accident Prevention

People / Environment / Work
Force / Frequency / Posture

FPST 3213

Equipment Design

Workstation / Equipment Design

https://www.youtube.com/watch?v=-UpxsrILbpU

Objectives

- Understand display design
- Understand different control design parameters
- Know how people will use different interfaces
- Be able to select the right tool

General Design Guidelines

- The goal of the ergonomist is designing equipment to be within the strength, endurance, reach, sensory, and information-processing capabilities of a large number of people

General Design Guidelines

- Machines are designed to improve the performance of the human system
- Machine sizing (“right-sizing”) should consider

Maintenance

- Horizontal clearance of at least 46” each side
- Vertical clearance of 80” if it requires overhead maintenance
- Access to components should accommodate both hands
- 1.8” clearance around each side of a component to be grasped

Maintenance

- Need to see equipment
- Lock-out/Tag-out
- Replaceable units

Displays

This one…

…or this one?

Displays

- Need to know
- Nice to know
- Historical

Displays

- Tactile/haptic
- Auditory
- Visual

Visual Versus Auditory Presentation of Communication in a Production Environment (adapted from Deatherage 1972; Ivergard 1999)

Use visual presentation if:

- The person's job allows him or her to remain in one position
- The message does not call for immediate action
- The message is complex
- The message is long
- The message will be referred to later
- The auditory system of the person is overburdened
- The message deals with location in space
- The receiving location is too noisy

Use auditory presentation if:

- The person's job requires him or her to move about continually
- The message calls for immediate action, as auditory alarms can be detected from any direction
- The message is simple
- The message is short
- The message will not be referred to later
- The visual system of the person is overburdened
- The message deals with events in time
- The receiving location is too bright or if preservation of dark adaptation is necessary
- The signal is originally acoustic
- The operator lacks training and experience of coded messages
- The situation is stressful and additional attention-getting is needed

Use tonal presentation rather than speech if:

- The operator is trained to understand coded messages
- In situations where it is difficult to hear speech (tones can be heard in situations where speech is inaudible)
- Where it is undesirable or unnecessary for others to understand the message
- If the operator's job involves constant talking
- In cases where speech could interfere with other speech messages

Visual Displays

- Static

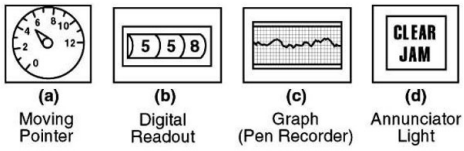
- Dynamic
  - Light
  - Instrument
  - Electronic

Light Displays

- A basic lamp display is usually color-coded and size-coded
  - Red
    - Danger, warning, fire
    - Small red – malfunction
    - Large RED – emergency condition
  - Yellow
    - Caution, slow, power on
  - Green
    - Go, ready, functioning correctly

Examples of Visual Displays

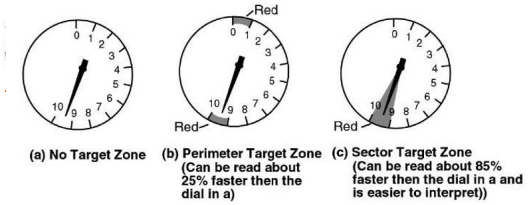
- An annunciator light typically has written instructions on it



(a) Moving Pointer (b) Digital Readout (c) Graph (Pen Recorder) (d) Annunciator Light

Instrument Displays

- Circular or semicircular dials are preferable to rectangular gauges
- Should only have two, four, or five marked intervals in between to avoid confusion
- Place zero at the 9 o'clock or 12 o'clock position
- Make the direction of increasing value

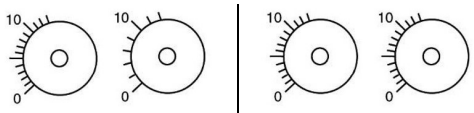


(a) No Target Zone

(b) Perimeter Target Zone (Can be read about 25% faster then the dial in a)

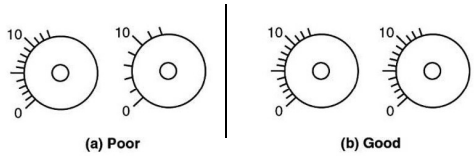
(c) Sector Target Zone (Can be read about 85% faster then the dial in a and is easier to interpret))

Why?



(a) Poor

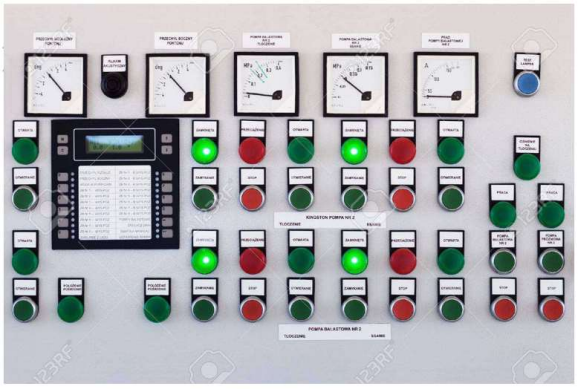
(b) Good



(a) Poor

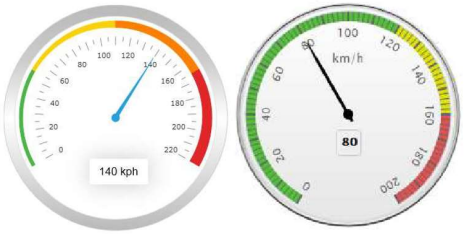
(b) Good

Conformity

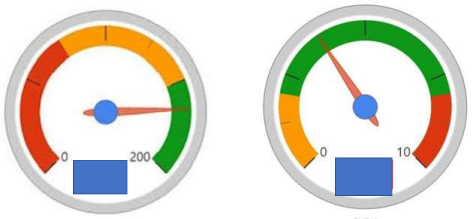


Maximums should be to the right

Use whole numbers oriented upright not radially



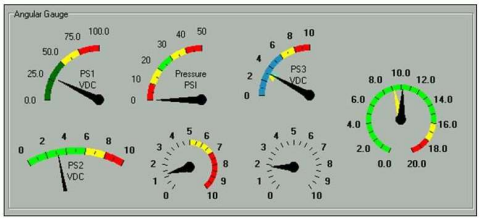
Avoid the need for interpolation for quantitative readings



Avoid the need for interpolation for quantitative readings

Instrument Displays

- Rapid reading = faster response time
- Use white markings on a black background
- Digital vs analog



Minimum Diameter of Inner Ring Inside the Scale Markings of a Dial at Various Viewing Distances (adapted from Woodson, Tillman, and Tillman 1992)

No. of Scale Marks	Viewing Distance				
	50 cm (20 in.)	91 cm (3 ft.)	1.8 m (6 ft.)	3.6 m (12 ft.)	6 m (20 ft.)
50		3.3 cm (1.3 in.)	6.6 cm (2.6 in.)	13 cm (5.0 in.)	23 cm (9.0 in.)
100	3.5 cm (1.4 in.)	6.6 (2.6)	12.7 (5.0)	25.4 (10.0)	43.2 (17.0)
150	5.1 (2.0)	9.9 (3.9)	20.3 (8.0)	38.0 (15.0)	66.0 (26.0)
200	7.4 (2.9)	12.7 (5.0)	25.4 (10.0)	53.3 (21.0)	86.4 (34.0)
250	8.9 (3.5)	16.3 (6.4)	33.0 (13.0)	66.0 (26.0)	109.2 (43.0)
300	10.2 (4.0)	19.5 (7.7)	38.0 (15.0)	78.7 (31.0)	129.5 (51.0)
350	12.7 (5.0)	22.9 (9.0)	45.7 (18.0)	91.4 (36.0)	152.4 (60.0)

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Instrument Displays

- Installation
  - Avoid shadows and optical distortion
  - Align groups of dials uniformly
  - Provide adequate illumination
  - Clearly labeled
  - Remove or cover unused displays

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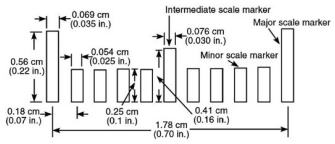
Instrument Displays

- Ensure the markings are of sufficient thickness to be discernable from the viewing distance



- Recommended scale mark dimensions for 28” viewing distance

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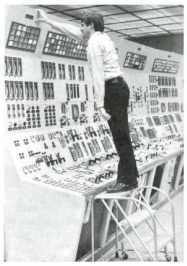
Instrument Displays

- Installation
  - Standing work: between 42” and 62” from the floor
  - Seated work: no higher than 20” above the work service



Electronic Displays

- Organization of information
- Design of graphical objects
- Coding techniques
- LED most common method

LED stands for **Light Emitting Diode**
CRT stands for **Cathode-Ray Tube**

Electronic Displays

- CRT versus LED
  - LEDs have superior contrast
  - Do not flicker
  - Lighter weight and smaller footprint
  - CRTs have wider viewing angles

CRT stands for **Cathode-Ray Tube**
LED stands for **Light Emitting Diode**

Guideline for LED Displays

- Minimize the use of segmented alphanumeric

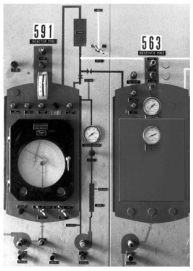
Good example?

Guideline for LED Displays

- Vertical numbers

Controls

Design of Controls



- A control is anything used by a person to affect performance of a system such as ……

Control Design, Selection and Location

- Minimum
- Frequent posture adjustment
- Use hand control for precision operation
- Use feet controls for large forces
- Distinguish between normal and emergency operations

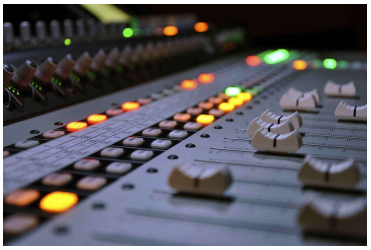
Prevent accidental activation of controls

Spacing

Control	Type of Use	Measurement of Separation	Recommended Separation: Minimum mm	Minimum in.	Desirable mm	Desirable in.
Push Button	One Finger (Randomly)		12	½	51	2
	One Finger (Sequentially)		6	¼	25	1
	Different Fingers (Randomly or Sequentially)		12	½	12	½
Toggle Switch	One Finger (Randomly)		20	¾	51	2
	One Finger (Sequentially)		12	½	25	1
	Different Fingers (Randomly or Sequentially)		16	⅝	20	¾
Crank and Lever	One Hand (Randomly)		51	2	100	4
	Two Hands (Simultaneously)		76	3	127	5
Knob	One Hand (Randomly)		25	1	51	2
	Two Hands (Simultaneously)		76	3	127	5
Pedal	One Foot (Randomly)		d = 100 D = 203	4 8	152 254	6 10
	One Foot (Sequentially)		d = 51 D = 152	2 6	100 203	4 8

Shape coding

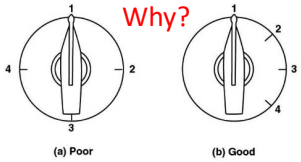
- Varying the shape, size and color on complex panels



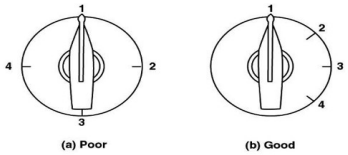
Control Resistance

- Design controls so that they
  - Are large enough to grasp
    - Less than 22 psi grip pressure

Why?



Control Resistance



Have the shortest amount of movement

Control Resistance

- Provide a positive indication of activation so malfunction is obvious
- Provide feedback to the operator
- Integrate use of arms or foot support to avoid static loading
- Provide a backrest for seated operator if push force greater than 22 N

Control Types

- Toggle switches
  - Used when operation has only two options
    - On/off

Control Types

- Push buttons
  - Frequently used to enter information into a piece of equipment for each button represents a separate response
    - Vending machine

Control Types

- Rotary selector switches
  - 3 to 24 values

Control Types

- Knobs
  - Extend the range of rotary selector switches
  - Can be rotated more than 360°

Control Types

- Valves
  - Denote direction of operation
  - Label as
    - normally open (NO)
    - normally closed (NC)

Control Types

- Crank
  - Provide either fine or course adjustment over a wide range

Control Types

- Levers
  - Useful in providing accurate adjustment over a small range

Control Types

- Hand wheels
  - Used for two handed operation when high force is required

Behavioral stereotypes

- Very loud sounds or blinking visual displays imply _____
- Large or dark objects denote _____
- Small or light-colored objects denote _____
- In addition to red, yellow, and green, blue indicates ____
- Coolness associated with _____ and warmth is associated with _____

Control movement stereotypes

TABLE 4.6
General Movement Expectations of Controls (adapted from Alexander 1976; Woodson, Tillman, and Tillman 1992)

Function	Direction of Control Movement
*On/start/engage	*Up, right, forward, press†
*Off/stop/disengage	*Down, left, rearward, pull†
Right	right, clockwise
Left	left, counterclockwise
Up	Up,rearward
Down	Down, forward
Retract (raising)	Up, rearward, counterclockwise, pull
Extend (lowering)	Down, forward, clockwise, push
Increase	Up,right, forward, clockwise‡
Decrease	Down, left, rearward, counterclockwise‡
Open (liquids, gases, doors)	Down,left, counterclockwise
Close (liquids, gases, doors)	Up, right, clockwise

This one…

…or this one?

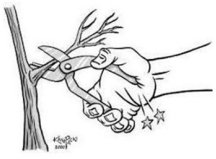
Tools

Tools

https://www.youtube.com/watch?v=tDvV0pYOISQ

The best tool is one that…

- Fits the job you are doing
- Fits the work space available
- Fits your hand and force
- Can be used in a comfortable work position
- It is safe in all aspects



Key concepts

- Understanding the User
- Computer Interface
- Matching Expectations

Understanding the User

- Limits of human memory and attention
- Early in the design stage, gather user characteristics such as _____

Matching Expectations

- System should tell operator
  - Where they are
  - What they have done
  - Whether it was successful

Matching Expectations

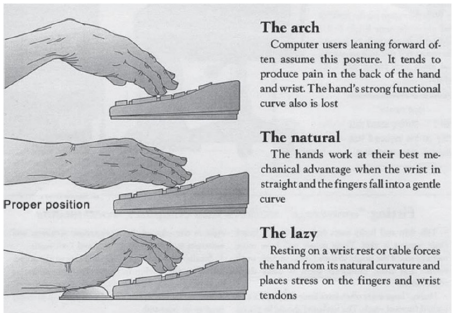
- Don't describe the symptoms of a problem, tell the operator the cause
- Keep false alarm rate low
- Make controls self-explanatory

Computer Devices

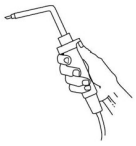
Computer Input Device

SmartFish ergonomic keyboard and tilting mouse

http://www.youtube.com/watch?v=c3Cwfz25Jeg

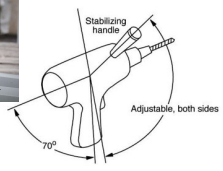


Working with a Soldering Iron



Extended and bent tip, elbows closer to his side
Reduce muscle fatigue

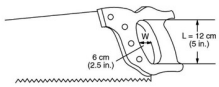
Electric Drill with Stabilizing Handle



Give the operator the opportunity to use the other hand to stabilize it

Saw Handle Dimensions

- Keeps the wrist closer to neutral
- Length of the hole no less than 5”
- Width should be at least 2.5”



Double-handle Tools

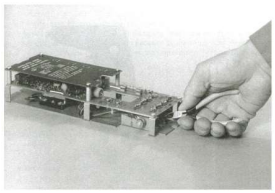
Closed grip span

Open grip span

- Tool with a grip span at least 2.5” when fully closed and no more than 3.5” inches when fully open
- Use tools that spring open

Safety Aspects

Safety Aspects



- Ensure handles are long enough

Safety Aspects

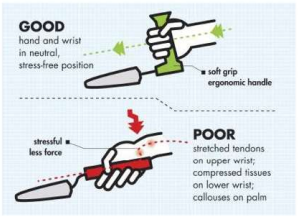
- Holding tool for a chisel

- Martor safety knife

Safety Aspects

- Martor safety knife
- Safety knife MARTOR SECUPRO 625 product video GB - Bing video

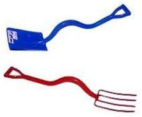
Tool Designs



https://www.youtube.com/watch?v=E9DVp7YvQVU

Tool Designs

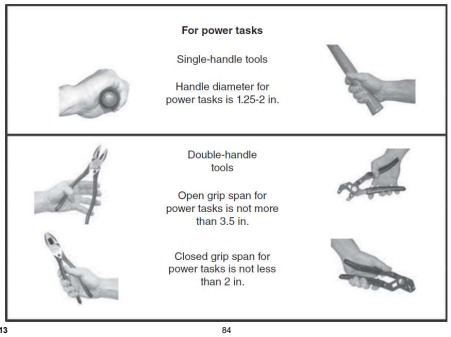
Tool Designs



Tools

Tools

https://www.youtube.com/watch?v=i6WMPSnFoQY



For precision tasks

Single-handle tools

Handle diameter for precision tasks is 0.25-0.5 in.

Double-handle tools

Open grip span for precision tasks is not more than 3 in.

Closed grip span for power tasks is not less than 1 in.

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Whenever possible use a power grip

FPST 3213 86

Use the handle that is best suited for the task

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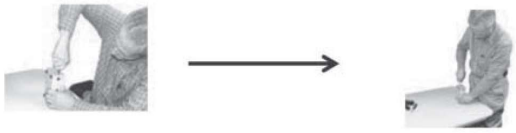

Posture can affect the performance of a task

Additional Tool Selection Guidelines

- Handle Length at least 5”
- Proper handle thickness
  - Vibration absorbing material if needed
- Strip trigger instead of single finger
  - Avoid thumb triggers
- Weight less than 5 pounds
  - If more, then use a balancer
- Precision tool weight less than 1 pound

Power tools

- Force to active it!

Ergonomic Balancer

https://www.youtube.com/watch?v=wjb3zo06bOI

Tools

Tools

To do list

- HW 6
- HW 7