X-Ray Therapy Systems

Xstrahl 200 Technical Manual

CE 0088

Xstrahl Limited GU15 3YL
Language: English

About Us

Xstrahl Limited produces specialist clinical solutions for medical practitioners and their cancer and dermatology patients by offering a range of superficial and orthovoltage X-Ray Therapy Systems, as well as a comprehensive *Superficial Therapy Educational (STEP) Program* for training and support.

Trademark

Xstrahl® is a registered trademark of Xstrahl Limited.

Notice of Copyright

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To improve reliability, function or design, Xstrahl reserves the right to change the product and/or this manual without notice.

Compliance

The design of Xstrahl Systems is in compliance with internationally recognised standards for safety. Xstrahl's range of X-Ray therapy systems are classified as *Class IIb Medical Devices* in accordance with the *Medical Devices Directive.*

All Xstrahl products have received CE marking approval for sale in Europe, clearance by FDA for sale in the U.S.A., are licensed for sale in Canada and are designed and manufactured in accordance with an ISO13485:2003 Certified Quality Management System.

Classification of Equipment (ME)

Xstrahl's X-Ray Therapy Systems are *Class I Medical Electrical Equipment* as defined in EN60601-1. They are classified for continuous operation and intermittent loading. All systems are specified IP0X for environmental protection.

File No., Revision, Year

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This document and all accompanying documents have been drafted in the English language.

Acknowledgements

All manufacturer tradenames and trademarks appearing in this document are hereby acknowledged.

Referenced Documents

Not all documents referred to in this document are part of the scope of delivery for the equipment. Xstrahl Limited reserves the right to determine the documents delivered with the product.

Instructions for installing this equipment are contained within the *Xstrahl Installation Manual* which is available to approved installation engineers.

Compatibility/Contra indications

Xstrahl X-Ray Therapy Systems must be used only in combination with components expressly recognised by Xstrahl Limited as compatible with *Xstrahl X-Ray Therapy Systems*. Before using any equipment or component not supplied by Xstrahl Limited, consult Xstrahl Limited for advice on compatibility.

The use of components other than those specified by Xstrahl Limited may affect electromagnetic compatibility (EMC) performance and result in increased emissions or decreased immunity of the equipment.

Modification of Equipment

Changes and/or additions to *Xstrahl X-Ray Therapy Systems* must be performed only by persons expressly authorised by Xstrahl Limited. Such changes must comply with best engineering practice and all applicable laws and regulations within the jurisdiction.

Any modifications during the service life of the equipment requires evaluation to the requirements of EN60601-1 and EN60601-2-8.

Environmental Conditions

Xstrahl systems are designed to operate within the following environmental conditions:

Ambient Humidity:	10 to 85% (non-condensing)
Operating Temperature:	10 to 30º Celsius

The storage temperature for all Xstrahl systems (non-operating conditions) must not exceed the following limits:

Ambient Humidity:	10 to 85% (non-condensing)
Storage Temperature:	5 to 40º Celsius

Note: Ensure the shipping box for the system and generator are stored upright and the boxes are not stacked at any time.

Portable Personal Electronic Devices

Portable personal electronic devices (intravenous pumps, cardiac pacemakers, intravenous devices and other implanted devices) should not be placed in front of a radiation beam. Small doses of radiation could cause the devices to malfunction. Failure to observe this warning could cause these devices to malfunction which could result in serious injury or

even death. Always monitor the operation of portable personal electronic devices during radiation treatment.

Intended Audience

The information contained in this manual is intended solely for the use of trained and competent medical operators preferably trained by Xstrahl Limited or an authorised person. Training requirements vary by country. Operators must ensure that training is provided in accordance with all applicable local laws and regulations.

Training

All operators must have the required training before attempting to operate the X*strahl's X-Ray Therapy System*. Because countries have different regulations for training, the operator must be compliant with the local laws and regulations of the jurisdiction in which the equipment is installed.

Glossary

The following Glossary explains acronyms, abbreviations and special terms which could appear in this manual:

Glossary	
A	ampere (amp)
ADC	analogue to digital converter
AC	alternating current
AUX	auxiliary
Cal	calibration
CE	Conformité Européene
CCU	central control unit
DAC	digital to analogue converter
DC	direct current
DMM	digital multimetre
EHT	extra high tension
EMC	electromagnetic compatibility
ESD	electrostatic discharge
GUI	graphic user interface
HT	high tension
HVL	half value layer
Hz	Hertz
IEC	International Electrotechnical Commission
Kg	kilogram
kV	kilovolt
kW	kilowatt
LCD	liquid crystal display
mA	milliampere (milli-amp)

Glossary	
mm	millimetre
mV	millivolt
MCB	miniature circuit breaker
MU	(radiation) monitor unit
PC	personal computer
PCB	printed circuit board
PDF	portable document file
PPE	personal protective equipment
PSU	power supply unit
sq	square
SSD	source to surface distance
SSR	solid state relay
T/D	time/dose
TFT	thin film transistor
TP2	therapy panel 2 (medical controller)
V	volts
VA	volts ampere
Vac	volts a.c. (alternating current)

Warnings and Cautions

All potential hazards to the health of personnel and to the integrity of Xstrahl's equipment are presented as *Warning* and *Caution* notices.

All Warning and Caution notices in this manual will appear at the point of application.

Sample Warnings and Cautions:

WARNING: Warnings alert operators to potential hazards to personal health and safety. Each warning explains the nature of the hazard, states the means by which the risk can be avoided and explains the consequences of failing to observe the warning.

CAUTION: Cautions alert operators to the potential risk of damage to the equipment or the environment, but not of hazards to health and safety. Each caution explains the nature of the hazard, the means by which the risk can be avoided and explains the consequences of failing to observe the caution.

Note:	A note provides important information about related content.

Specific Hazards

Xstrahl X-Ray Therapy Systems have system specific hazards which are a potential risk to both personnel and equipment. All specific hazard notices in this manual will appear at the point of application.

Sample specific hazards:

RADIATION: *Xstrahl X-Ray Therapy Systems* generate ionising radiation which can cause death or injury if precautions are not adhered to.

HIGH VOLTAGE: High voltages are present in all *Xstrahl X-Ray Therapy Systems* when the system is connected to the mains electrical supply. Exercise extreme caution and isolate the mains electrical supply before attempting to connect any cables or open any service or access doors on equipment.

PROTECTIVE EARTH: Protective earth labels are placed next to protective earth terminal studs. Ensure earth terminals are connected to system earth at installation and before operating the equipment. If any protective earth point is disconnected, the equipment must not be used.

DANGER HIGH VOLTAGE, ISOLATE SUPPLY: Before opening access panel, isolate the main supply. High voltage components and wiring are present inside the access panel.

Safety

All operators of this equipment must read, obey and understand all safety warnings, cautions, notes and safety labels on equipment.

All operators must read and understand all information in this document.

Intended Function (of equipment)

Xstrahl's range of superficial and orthovoltage *X-Ray Therapy Systems* are intended to assist in the delivery of radiation to a defined target volume whilst sparing surrounding normal tissue and critical organs from excess radiation.

Intended Use (of equipment)

Xstrahl® (100, 150, 200 and 300) X-Ray Therapy Systems are intended to be used for radiation treatment of superficial skin disorders, boney metastases and diseases of the skin, as determined by a licensed medical practitioner where the system is being used. They are intended to be used for single or fractionated treatment (dose or time depending on system). Treatment should always be determined by a licensed medical practitioner in the jurisdiction where the system is being used.

Note: In the United States, Federal law restricts the sale of these devices, distribution and use by, or on or order of, a licensed physician.

Intended Function (of document)

The intended function of this document is to assist the operator in the safe and correct operation, application and preventative maintenance of the equipment. The operator is the authority who has the control of the equipment and the person(s) who operates and works on the equipment.

Xstrahl recommends this document be kept with the equipment at all times.

Document Amendment Table

Xstrahl, at their discretion, may update sections of this document after first issue. Updated document amendments will be marked by an identifying release date which can be found at the bottom of all document pages (*for example*, 13/6/13).

It is the responsibility of the operator to update the following Document Amendment Table as new document amendments are issued:

Document Amendment Table			
No.	**Section**	**Release Date**	**Authorised By**

EC Declaration of Conformity	
Xstrahl Limited declares that the following equipment conforms to all relevant essential requirements and provisions of the Medical Devices Directive 93/42/EEC Annex I and Annex II (excluding section 4) and the UK Medical Devices Regulations 2002 No. 618, as amended by the Medical Devices (Amendment) Regulations 2008 No. 2936.	
Equipment:	Xstrahl X-Ray Therapy Systems
System Type:	
Serial Number:	
Manufacturer:	Xstrahl Limited The Coliseum, Watchmoor Park Riverside Way, Camberley Surrey, GU15 3YL United Kingdom
EC Certificate of Approval Number:	LRQ 0961574/B
Notified Body:	LRQA Limited Hiramford Middlemarch Office Village Siskin Drive Coventry, CV3 4FJ
Registration No. of Notified Body:	0088
Xstrahl Limited confirms that the equipment described above is manufactured in accordance with an ISO 13485:2003 Quality Management System approved by LRQA–QMS Certificate Number 0961574/A.	
Name and Address of the Responsible Person within the EEC:	
Name:	M. Robinson, Chief Executive
Address:	Xstrahl Limited The Coliseum, Watchmoor Park Riverside Way, Camberley Surrey, GU15 3YL United Kingdom
Signature of the Responsible Person (or Person Empowered to sign on his behalf):	
Signature:	
Name:	
Date:	

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Preface

This is the *Technical Manual for the Xstrahl 200*. This manual provides the information required to diagnose, manage and calibrate an Xstrahl system.

1 Xstrahl 200 System Description

This section provides a thorough and detailed description of the Xstrahl 200 system features. These features include the operator pod, interface, desktop, computer controlled EHT generator, tube stand assembly, dosimetry and temperature measurement, X-Ray tube cooler, safety interlocks, warning lamps and a detailed description of the primary communication channels.

2 Control System

This section provides an indepth technical description of the Xstrahl TP2 Control System. This includes a mechanical description of the peripherals, connections, settings, safety system overview, spare parts list and system circuit drawings.

3 Fisica

This section provides a complete overview of the Fisica interface; Fisica enables configuration of the controller and peripherals, and calibration of the system.

4 Time/Dose Control Systems

This section provides the serial data connection information which controls the microprocessor controllers and real time clocks of the Xstrahl 200 system.

5 X-Ray Tube, Filters and Applicators

This section provides a technical data overview for the X-Ray tube, filters and applicators that are supplied with the Xstrahl 200.

6 HT Generator

This section provides information on the Xstrahl 200 CP Series generator. Refer to the *CP Series Technical Manual pdf* included with this manual for a detailed description of the generator.

7 200 Tube Stand

This section provides a description of the Xstrahl 200 floor/wall stand and ceiling track system; this includes an overview of the cable connection, transit wheels, cooling system and support arm.

8 **Cooling System**

This section provides detailed information on the Xstrahl 200 water cooling system and specifications.

A **Preventive Maintenance Procedures**

B **Error Code Table**

C **Notes**

About **About Xstrahl**

See also the About Xstrahl section in the front of this manual for more general information. This section includes an *EC Declaration of Conformity* form.

Section 1:

Xstrahl 200 System Description

in this section

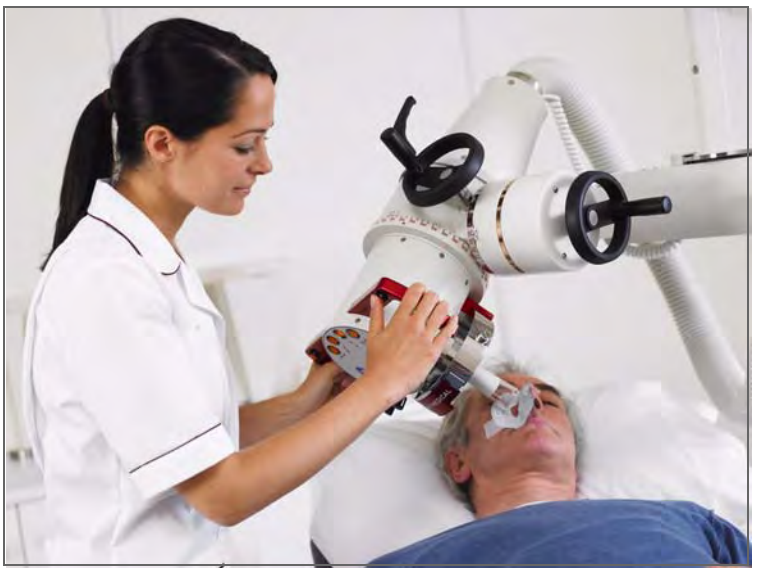
1 Xstrahl 200 System Description

RADIATION: X-Ray equipment emits ionising radiation and is dangerous to both operator and personnel within close proximity. To avoid risk of injury, observe all safety measures and ensure you are adequately trained prior to operating this equipment.

superficial X-Ray therapy

The Xstrahl 200 is a superficial X-Ray therapy system which produces X-Rays from 20 kV to 220 kV. The energy of the beam is defined as the *half value layer*—it is dependent on the kV selected and the filter materials placed within the X-Ray beam.

Figure 1–1: Xstrahl 200 Illustration



1.1 Features

The following peripherals are controlled by the TP2:

- Operator pod
- Computer controlled EHT generator
- Tube stand assembly, including tube, filter and applicator housing
- Dosimetry and temperature measurement
- Safety system (interlocks)
- X-Ray tube cooler
- Warning lamps

1.1.1 Operator Interface

The TP2 operator interface is comprised of:

- a PC running Xstrahl software and
- an operator pod

1.1.2 Desktop

The desktop is configured for each system by four key databases which (subject to authority) are written to the TP2 by the Fisica program. These databases are stored on the desktop.

The databases which configure the system include the required generator type and tube type so the TP2 can browse through its communication channel to the EHT generator to ensure it is configured correctly.

1.1.3 Operator Pod

The TP2 is connected to the operator PC through a serial connection from the operator control pod. The operator pod is connected to the TP2 through a multi-core cable.

The operator control pod features:

- Emergency Stop
- Power On Lamp
- X-Ray On Lamp
- X-Ray On Button (illuminated)
- X-Ray Off Button (illuminated)

1.1.4 Communication

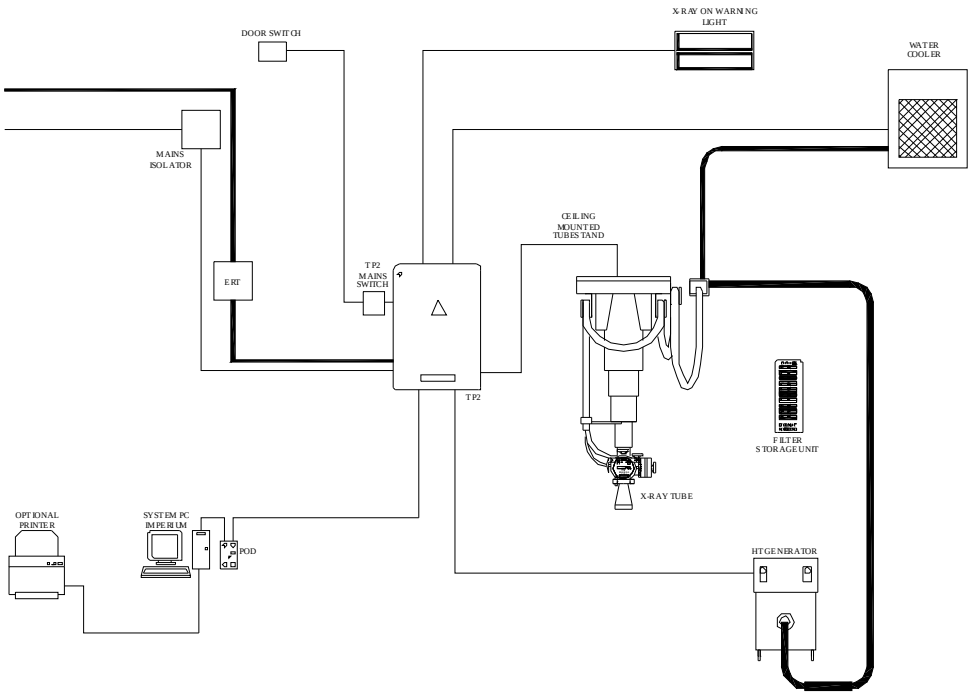
The TP2 has two primary communication channels; PC and TP2 and TP2 and EHT generator.

A different type of generator is provided for each system. The generator is further configured to a specific X-Ray tube type, including its recommended warm-up (tube conditioning) programs. The micro-processor controller in the generator is in constant communications with the TP2 during an exposure.

The generator not only controls the kV and mA delivered to the tube, but also contains a programmable timer. In Xstrahl time systems, the generator runs the primary timer and the TP2 runs the backup timer. The times are cross-checked to ensure compatible time increments. The generator further monitors its own X-Ray use and can recommend a suitable warm-up profile based on hours off.

In addition to the Xstrahl software (screen displays) running on the desktop, there is an LCD display on the front of the TP2 CCU, which in the event of a power failure, will display the treatment status (filter number, applicator code, delivered treatment and set time).

Figure 1–2: TP2 Control System (Xstrahl 200)



1.2 Electrical Specifications

Xstrahl 200 kV Electrical Specifications	
Power requirements	8 kVA single phase AC[a]
Mains supply	220 V ± 10% (198 to 242 VAC)
Nominal frequency	47 to 63 Hz

a. Once the Xstrahl system is installed and the system setup complete, the mains input must remain stable within ± 7 V of the voltage at installation.

1.3 Generator Power Considerations

The *Xstrahl X-Ray Therapy System* requires a stable mains power supply at all times. It is specified 220V ±10%, but this is the maximum acceptable supply range.

Once the Xstrahl system is installed and the system setup is complete, the mains input must remain stable with ±7V of the voltage at installation.

Note: When the mains stability cannot be guaranteed within this range, consideration should be given to installation of suitable power conditioning (*for example*, constant voltage transformer).

The auxiliary transformer in the generator (generator converter chassis) has three voltage tappings:

- 200 VAC
- 220 VAC
- 240 VAC

Auxiliary Transformer Voltage Tappings[a]	
Nominal voltage 198 to 211 VAC	use 200V tapping
Nominal voltage 211 to 232 VAC	use 220V tapping
Nominal voltage 232 to 242 VAC	use 240V tapping

a. The auxiliary voltage transformer tappings will be set during system installation based on the monitored system supply voltage.

Section 2:

Control System

in this section

2 Control System

Note: This section provides circuit descriptions which apply to all Xstrahl series systems (100, 150, 200 and 300). If you are unsure of what information applies to your system, please contact Xstrahl.

WARNING: To avoid the risk of electric shock, this equipment must only be connected to a supply mains with a protective earth.

WARNING: No modification of this equipment is allowed.

WARNING: If this equipment is modified, appropriate inspection and testing must be conducted to ensure continued safe use of equipment.

2.1 TP2 Control System

This section provides a detailed description of the Xstrahl TP2 control system, including the hardware and circuitry. The Xstrahl TP2 introduces a central control unit (CCU) electronic cabinet which controls the Xstrahl 200 and operator interface (operator PC and control pod).

2.1.1 Mechanical Description

Mechanical Description: TP2 CCU Controller Enclosure			
Width	**Height**	**Depth**	**Weight**
500 mm	700 mm	255 mm	46 kg

2.1.2 Operator Control Pod

Figure 2–1: TP2 Operator Control Pod

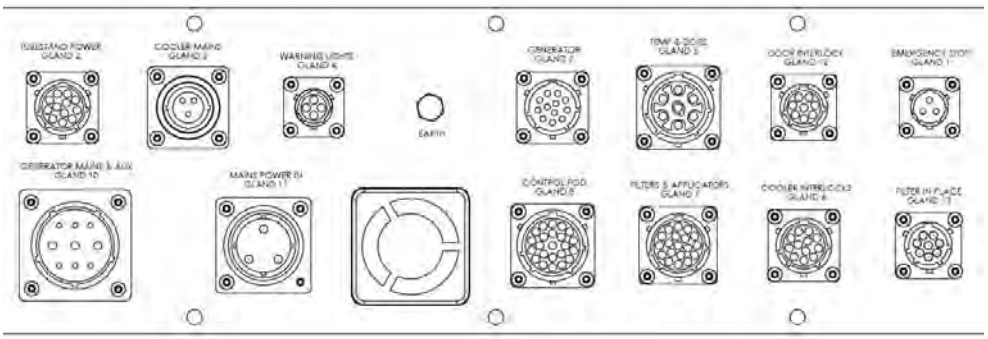
Operator Control Pod		
No.	**Function**	**Description**
1	X-Ray On (yellow) Indicator	Yellow flashing indicator. Blinks at 1 Hz during *X-Ray On* period and after the *X-Ray On* period is terminated (until the generator output falls below 5 kV). May be set to continuous; default is flashing on.
2	Power On Indicator	Clear (white) illuminated indicator. Illuminates when the key switch is turned to *Standby* (position 2) and maintains illumination in *HT On Enable* (position 3).
3	X-Ray On Button	Green illuminated button. When the key switch is turned to *HT On Enable* (position 3), all safety circuits are made and a valid treatment is loaded, the *X-Ray On* light will be illuminated. Pressing the button will initiate X-Rays; during X-Rays, the button illumination is extinguished with the *X-Ray Off* button illuminated.
4	X-Ray Off Button	Red illuminated button. Terminates *X-Ray On* mode at any time, but does not reset the elapsed time or dose display. *X-Ray Off* will illuminate when the *X-Ray On* sequence begins.

Operator Control Pod		
No.	**Function**	**Description**
5	Key Switch (3-position)	3-position key switch; no power "*O*" (position 1), Mains On *Standby* "|" (position 2) and *HT On Enable* (position 3)
6	Emergency Beam Off	Shuts down the system if pressed. Must be released to restart system.
7	Operator Pod Internal Access Key	Key opens the operator pod cover if the pod screws have been removed.

2.2 TP2 CCU Gland Plate Connections

PROTECTIVE EARTH: A *protective earth label* is placed next to protective earth terminal studs. Ensure earth terminals are connected to system earth at installation and before operating the equipment. If a protective earth point is disconnected, the equipment must not be used.

Figure 2–2: Gland Plate Connections



The TP2 CCU enclosure is connected to the TP2 peripherals through a gland plate mounted underneath the enclosure.

Gland Plate Connections		
No.	**Connection**	**Connector Type**
1	Emergency stop	3-way plug
2	Tube stand power	12-way socket
3	Cooler mains	3-way socket
4	Warning lights	4-way socket
5	Temp and dose[a]	7-way socket
6	Cooler interlocks	12-way socket
7	Filters and applicators	19-way socket
8	Control pod	23-way socket
9	Generator	12-way plug
10	Generator mains and AUX power	9-way socket

Gland Plate Connections		
No.	**Connection**	**Connector Type**
11	Mains power in	3-way plug
12	Door interlock	8-way socket
13	Filter in place[b]	9-way plug

a. Time based systems do not use connector 5
b. Only Xstrahl 150 systems use filter in place connector 13.

2.3 Isolating Equipment

HIGH VOLTAGE: High voltages are present in all Xstrahl X-Ray Therapy Systems when the system is connected to the mains electrical supply. Exercise extreme caution and isolate the mains electrical supply before opening any service or access doors on the equipment.

WARNING: Isolate the mains electrical supply before service or maintenance on the equipment.

To isolate the equipment, use the mains isolator switch on the side of the TP2 CCU enclosure (see Figure 2–3:). The isolator switch has provision for a padlock to permit the isolator switch to be locked during service and maintenance. After isolating the equipment, it is necessary to check with an electrical meter to confirm the mains supply has been isolated before working on the equipment.

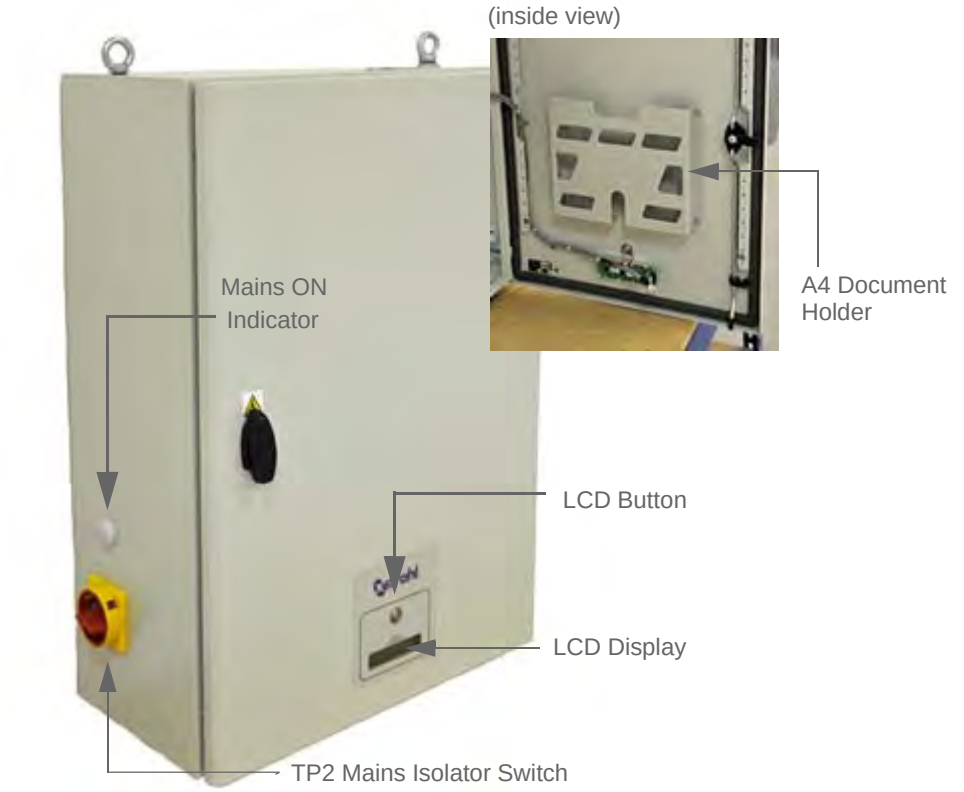
Note: The equipment must be externally isolated if working on the mains cable to the TP2 CCU or wiring to the TP2 CCU isolator switch.

Figure 2–3: Mains Isolator Switch

2.4 TP2 CCU Enclosure (Electrical Panel)

DANGER HIGH VOLTAGE, ISOLATE SUPPLY: Before opening the access panel, isolate the main supply. High voltage components and wiring are present inside the access panel.

Figure 2–4: CCU Controller Enclosure Illustration



TP2 CCU Enclosure (Front Panel)	
TP2 Mains Isolator Switch	Isolates mains power supply to the TP2 system
LCD Button	Press LCD button to display data on the LCD display during a mains power failure
Display On Power Fail LCD	Liquid crystal display (LCD) located on the front panel of the TP2 CCU. All data relating to the treatment in progress is stored in battery backed memory. In the event of a mains power failure resulting in the interruption of treatment and loss of the monitor display, the LCD will display the relevant information (*for example*, filter number, applicator letter, mode, delivered treatment/set treatment) on the front panel of the TP2 CCU. In the event of mains failure, press the LCD button to display data on LCD.
Mains On Indicator	Illuminates when there is power to the system
A4 Document Holder	Houses copy of TP2-1068 system diagram

The tube stand power options depend on the system and tube stand options as shown in Figure 2–7:.

Figure 2–5: TP2 Inner Door

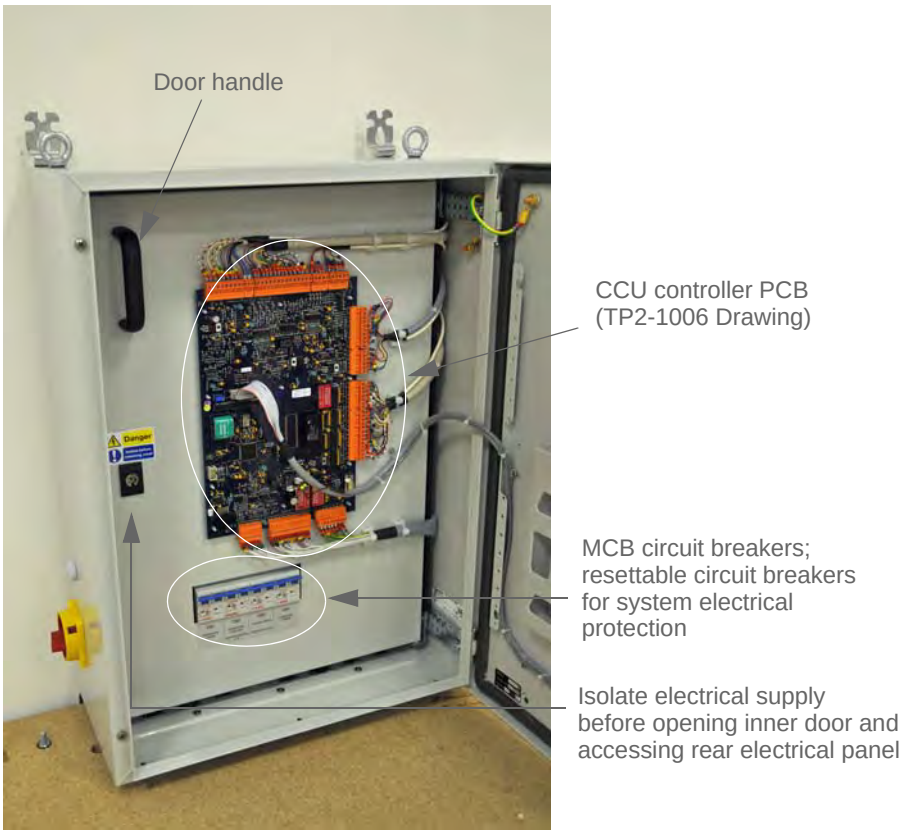
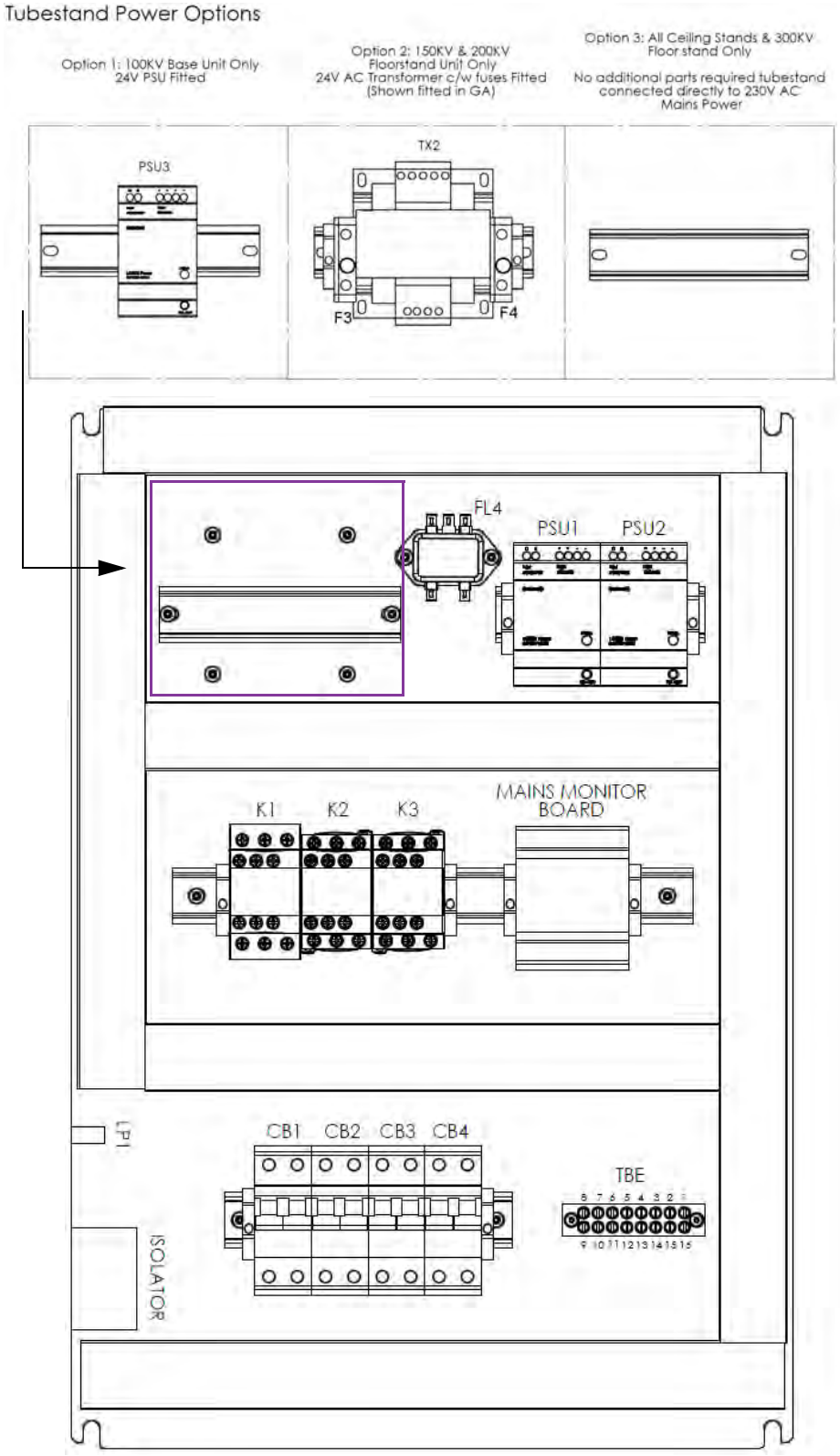


Figure 2–6: TP2 Rear Electrical Panel

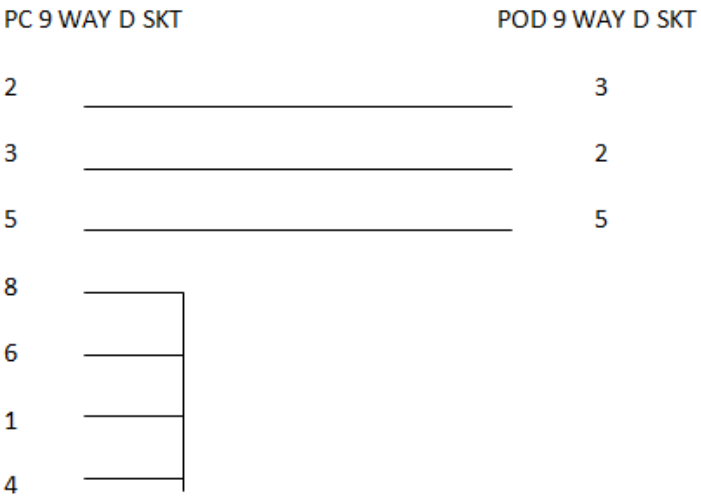
Figure 2–7: CCU Rear Electrical Panel Drawing



The TP2 CCU electrical panel is located behind the inner door of the CCU Controller enclosure.

2.5 RS-232 Connections

Figure 2–8: Typical PC Connections



The RS-232 serial connection is made using a null modem cable, whereby the null modem cable connects the local PC and the TP2 through the operator control pod. The only communication allowed on the null modem line is data-only traffic on the cross connected Rx/Tx lines. The reversing of the transmit and receive lines enables direct two-way communication only.

2.5.1 RS-232 Settings

The RS-232 interface is set to 9600 baud, 8 bits with 1 start bit and at least 1 stop bit. The most significant bit of the 8 is ignored and no handshake lines or software start/ stop protocols are used.

2.6 TP2 System Interconnect Diagrams

Note: See “TP2 Control System Drawings” on page 2.1-1.

The system interconnect diagrams (system specific) show the connection of the TP2 controller in respect to the high voltage generator, cooler, tube stand, operator control pod, operator PC and safety warning lights and safety interlocks.

2.7 TP2 Safety System Overview

Note: Please refer to drawings: B1—TP2 Safety System Overview on page 2.1-9 and B2—TP2 Safety System (Computer Controlled Gen) on page 2.1-10

This section provides an overview of the TP2 and generator safety and control.

The safety system acts to terminate high voltage from the generator, which in turn prevents the X-Ray tube from emitting X-Rays. The primary action of the safety system is to disconnect the main AC power from the generator.

2.7.1 Important Concepts (Safety System)

The computer controlled generator is powered by two separate AC power sources:

Auxiliary Power	The auxiliary power feeds the computer control, the filament supply and the cooling devices of the generator (high voltage power supply system). The power is connected when the key is in standby (position 2) or *HT On Enable* (position 3), except when the isolator on the side of the TP2 is turned off or when the *Emergency Off Button* is pressed. See Contactor K2 control in B1—TP2 Safety System Overview on page 2.1-9
Main Power	The main power feeds the power converter (of the generator), which is connected to the high voltage transformer and multipliers. While X-Ray initiation requires the high voltage circuits to be turned on and powered, it is considered a key element in the overall safety control to remove this power when X-Rays are to be inhibited. See Contactor K1 control in See Contactor K2 control in B1—TP2 Safety System Overview on page 2.1-9

2.7.2 X-Ray Initiation

Note: See generator connections in B1—TP2 Safety System Overview on page 2.1-9

In addition to the connection of mains power, the generator requires two hardware signals (*X-Ray Off* and *Interlock*) and a software command to initiate X-Rays. The *X-Ray On* button on the operator pod is illuminated when the key is in *HT* (position 3) and the TP2 is ready.

When the operator presses the *X-Ray On* button, the *X-Ray Off* interlock is sent to the generator and a software initiation command is sent to the generator. The *X-Ray Off* interlock must be maintained throughout the treatment, but can be removed by pressing the *X-Ray Off* button on the operator pod.

2.7.3 Cooler Control

Note: See B1—TP2 Safety System Overview on page 2.1-9

The cooler is powered on when contactor K3 is closed. A 24 V DC power supply produces an ‘Interlock+24 V’ voltage, which powers the interlock relay through the door and cooler switches. This power supply is powered when the cooler is powered. Additionally a contact of K3 (K3/3) is in circuit with the circuit enabling the K1

contactor feeding the mains supply to the generator. The processor maintains the cooler supply for a minimum time after the last treatment when the key is turned to *No Power* (position 1).

2.7.4 Key Switch

The key switch on the operator pod has three positions:

No Power (position 1)	No power to all systems unless the cooler is still running on the timer.
Standby (position 2)	Standby or auxiliary power to the generator and *Mains On + 24 V* power in the TP2, enabling both processors to run. This power must continue with the third key position, hence the key in series K2 being marked 2 and 3.
HT On Enable (position 3)	K1 is made if the processor in the TP2 is ready (therefore enabling K1), the interlock relay (RL2) is made, the cooler contactor is made and main power is connected to the generator.

2.7.5 TP2 Ready

TP2 ready is achieved if the clinical treatment loaded into the TP2 is valid and the generator has accepted the parameters.

2.7.6 Treatment Valid List (non-exhaustive)

- Filter in use
- Filter calibrated (dose systems only)
- Applicator in use
- Applicator calibrated for use with filter (dose systems only)
- Treatment time less than maximum
- Dose setting less than maximum (dose systems only)
- Correct filter fitted
- Correct applicator fitted (not Xstrahl 150)
- TP2 LCD display is working
- TP2 has no fatal errors or faults
- kV within generator range
- mA within generator range
- Generator set to medical start-up
- Generator matches TP2 generator and X-Ray tube ID’s
- Generator has no fatal errors or faults

2.7.7 Watchdog

A *Watchdog* is a timer which runs to reset the processor to a safe state. The programme must regularly clear the *Watchdog* to prevent itself from being reset. If a programme fails to run at a particular point in the normal code or starts performing some random code, then the *Watchdog* will not be cleared.

A *Watchdog trigger* is of type fault. Both processors in the TP2 and the generator have separate *Watchdogs*.

2.7.8 Polling

During treatment, the external control PC must send a lock signal at least once per second to keep the TP2 in an *X-Ray On* state. Also during treatment, the TP2 must send a lock signal at least once per second to keep the generator in an *X-Ray On* state.

2.7.9 Dual Control

Note: See B2—TP2 Safety System (Computer Controlled Gen) on page 2.1-10

There is an RS-422 serial link between the TP2 and the generator, and an RS-232 link between the TP2 and the external (interface) PC. The processors in the TP2 and the generator (not the PC) provide a dual control system and they check each other to ensure the same time increment.

In a dose system, the TP2 processor provides primary control of delivered dose and the generator runs to a computed back up time. This time is computed from the value of the dose treatment and the expected rate of the calibration data. In time systems, the generator processor provides primary control of treatment time and the TP2 runs to an independent, but identical time increment and to a slightly longer target time.

2.8 TP2 Circuit Descriptions

2.8.1 TP2 System Diagram

Note: See TP2 System Diagram TP2–1068 on page 2.1-11

The TP2 system diagram above details the layout and connections of the TP2 controller.

There are two principal circuit boards within the TP2 CCU:

CCU Control PCB	The control PCB contains all protection, interlocks and 5 V, 12 V and 24 V interface circuitry for the filters, applicators, interlocks, generator and RS-232 link. All signals are then processed and controlled with the freescale processor and embedded software.
Mains Monitoring PCB	This PCB contains the 230 V AC supply functions, including mains monitoring, warning light monitoring and the warning light output lines for controlled area and *HT On*.

2.8.2 Circuit Description

The AC supply enters the circular connector Gland 11. This supply is fed from the mains contactor (K2) in the TP2 CCU, which is energised through the operator pod key switch in *Standby* (position 2). The contact of the main key switch is closed when the key is in positions 2 and 3.

The power supply (220 V AC) to the generator is fed in two separate circuits from the same phase, from the circular connector Gland 10. The auxiliary power supplies

the fans, interface and filament. The main power supply feeds the EHT circuits.

The auxiliary power is connected from the same mains contactor (K2), feeding when the key switch is in position 2 and 3. Main power to the generator is switched by the EHT contactor (K1) in the TP2 CCU. The EHT contactor is energised when the key switch is in position 3 and all interlocks made on the CPU PCB. The generator interface control is fed from the circular connector Gland 9. *X-Ray On* and *Off* switching is made with push button switches on the operator pod.

2.8.3 CCU Control PCB Circuit Diagrams

Note: See CCU Control Board Schematic TP2–1006 (1–5) on page 2.1-12

The TP2 CCU control PCB provides the core of the TP2.

The CCU Control Board Schematics in diagrams 1-5 include the following sections:

- Power control and operator pod circuits
- Filter and applicator sensing
- Safety circuits
- X-Ray generator interface
- CPU/memory and associated peripheral circuits
- Temp and dose interface (not used on time systems)
- Pressure sensor (not used on time systems)

The above sections are opto-isolated from each other, but are ground referenced to the earth bus to reduce the possible effects of noise on a distributed site.

Each of the connectors on the CCU control PCB have been selected to be different by either the number of ways or its pitch to ensure they should not be misconnected. The groups on each connector are functionally and physically related.

for example

The filter connections, the dosimeter input and thermocouple sensing circuits are on PL10, PL11 and Pl12 and are then routed to the tube head.

The schematic circuits are detailed by function on sheets 1 to 5 of the CCU Control Board Schematic TP2-1006.

2.8.4 TP2-1006 Sheet 1 of 5 (Filter Selection and Dosimeter Buffer)

Note: See CCU Control Board Schematic TP2–1006 (1–5) on page 2.1-12

All 16 identical opto-isolated filter circuits are provided on two connectors PL11 and PL12, grouped to allow for filters 0 to 9, filter fitted, power and applicators, applicator fitted and power signals separately. Power is supplied to the X-Ray tube

head as a DC voltage +12 V filters from U14, a DC/DC PSU supplied from +24 V AUX. This can withstand a continuous short circuit.

Power is also supplied to the temperature and dose PCB and the electrometer/ion chamber (not used for time-based systems). Each filter circuit has a current limiting resistor, protective diode and opto-isolator with its output transistor signal fed to the CPU (PAD8-23) through a pull down resistor.

2.8.5 TP2-1006 Sheet 2 of 5 (Thermocouple and Generator RS485 Interface)

Note: See CCU Control Board Schematic TP2–1006 (2–5) on page 2.1-13

The generator is interfaced by a serial communication signal, together with a separate status and interlock controls (PL7). For the TP2, this is interfaced by an RS485 serial line and only two of the control functions are implemented, X-Ray Off and Interlock.

The serial lines at PL7 are implemented by the RS485 driver/receiver U8. Resistive terminations are provided for the receiver and protection transorbs are fitted at D19, D20, D25 and D26. U5 and U13 give opto-isolation from the CPU signals PJ0 and PJ1. The CPU PT6 has an output line (low active) which through the opto-coupler U1, controls the X-Ray OFF signal (~2 mA). This current driven signal enables the generator to allow the X-Ray ON.

The generator circuit power comes from the isolated +24 V DC/+12 V DC converter U18 and the +5 V regulator U43. The LED, GEN +5 V indicates that it is powered when the +24 V AUX is active.

The thermocouple temperature measurement is transmitted to the CCU control board (TP2-1006) from the Temp and Dose board (TP2-1007) by means of a digital 1-Wire signal. The thermocouple measurement is converted to RS-232 by U2, opto-isolated by U3 and U17, with the digital temperature signal connected to the CPU on lines PH6 and PH7.

2.8.6 TP2-1006 Sheet 3 of 5 (CPU/Memory and Associated Peripheral Circuits)

Note: See CCU Control Board Schematic TP2–1006 (3–5) on page 2.1-14

The CPU/Memory and Associated Peripheral Circuits is the heart of the controller and is a freescale CPU (U32). This has a 16-bit CPU integrated with ports supporting an external bus, 8 bit A/D converters, serial (SCI) buses, timers and PWM controller, flash and ram memory, | / O ports and runs at a 40 MHz clock speed.

The CPU symbol shows the connections and port functions:

for example

Ports PA, PB, PK, PD and PE are associated with the external bus signals address, data and control signals.

Ports PH 6/7, PS 0/1, PS 3/4, PAD0, PAD1 are A/D inputs for the pressure sensor and the mains monitoring circuit.

PAD 8/23 is general | / O signals for the filters and applicators, etc.

Attached to the CPU symbol are the power filter components and the clock parts R109, X1, C49 and C53. The CPU has internal circuitry to safeguard power up and brown out conditions. The CPU is programmed into the internal flash memory and is loaded by means of the BDM connector PL14.

Note: This can only be enabled when R138 and LINK3 are fitted.

There is a battery backed external RAM/RTC (real time clock) device, U19 fitted and also an optional PROM U21 (not fitted). The CPU is normally powered from the +5 V through a switched mode regulator U15 (from the 24 V DC supply) to the 5 V DC converter (U21) IP5 V. This can be alternatively powered (for the emergency LCD display) from the 4.8 V battery B1 and relay RL-1. When the mains are off, it is activated from connector PL16 (LCD On button on the front panel of the TP2 CCU enclosure).

This battery is trickle charged from +5 V. There is a provision for a faster battery charge (fit link between PL18, pins 2 and 3) for initial set-up (max 24 hrs). An LED indicates that +5 V is present. For test/debug purposes, an RS232 interface is provided on PL13 (a 9-way D type connector) and its driver/receiver device (U11).

The emergency LCD display is connected through connector PL15 and switched by PL16 (LCD ON button connection) is provided for diagnostics and recovery of treatment information during power failure. It is buffered to the CPU by U31 and U39. RV1 controls the contrast for the LCD display.

LINK1 and LINK2 are software option bits enabling software options to the CPU signals PH4 and PH3. The pressure sensor U41 is present for corrections to the dosimeter; the analogue signal is buffered by U40 and converted from analogue to digital (8 bit) signal through PAD1 of the CPU (not used for time based systems).

An LED marked as PP4 is indicated for software use (port PP4).

2.8.7 TP2-1006 Sheet 4 of 5 (Mains Warning Lamp Control and Interlock Circuits)

Note: See CCU Control Board Schematic TP2–1006 (4–5) on page 2.1-15

The interlock circuit Interlock +24 V is powered from the cooler contactor (K3). This feeds to a series of switches; Cooler Flow (PL4/1 to PL4/2), Cooler Over Temperature (PL4/3 to PL4/4), Door Interlock1 and Door Interlock2 (PL5/1 to 5) and controls RL2. This produces an isolated interlock output to the Generator Interlock at PL7/5 to PL7/6 and allows (with other limits) K1 the Generator Main Power contactor to be activated.

Each switch has an opto-coupler that is fed to the CPU to indicate the status of each switch. The dual door switch system is connected to provide a fail safe system requiring three lines of PL5.

For an overview of the TP2 safety system:

- See B1—TP2 Safety System Overview on page 2.1-9
- See B1—TP2 Safety System Overview on page 2.1-9
- See B2—TP2 Safety System (Computer Controlled Gen) on page 2.1-10

When the safety switch chain is complete, +24 V is supplied to RL2. This enables the relay to be closed, provided that the CPU is set (PS4) to 0 V (enables U501 opto-isolator to be active and hence, switching on TR500). The control of PS4 is provided to check the Generator Main Power contactor K1 has not stuck and can be de-activated (even if the safety switches are closed on Power ON).

The other limits on activating K1 are the key switch (KEY3 on the operator pod) and the negative end of the coil of the DC contactor (Interlock Op). This sets PT0 of the CPU (Interlock ON) on low, activating opto-isolator U29-2 and enabling TR5 ON, causing Interlock Op low.

Additionally, there is a power feed +24V Mains In from the external PSU to connector PL2/6. This includes the link (PL1/1 and PL1/2) which ensures that the earth connectors from the star point to the separated isolated grounds of the individual circuits) are in place. Failure to fit this zero volt link will ensure that no power is provided to the CPU.

Mains Warning Light Drivers are provided on a separate Mains Monitoring PCB for safety purposes, but the control for these is on PL3. The *Controlled Area Light* is switched on by the +24 V AUX (PL3/1) signal set by the emergency switches being closed and activation is by the key switch KEY2 on the operator pod.

Setting low PH0 on the CPU causes opto-coupler U29-1 to activate and enables TR6 to conduct. This provides the current flow for the Do Not Enter light SSR (solid state relay) PL3/5, +24 being sourced from AUX +24 V.

Status signals from the current flow of the lights are detected on the *Mains Monitoring PCB* and are received at PL3/3 Control Area Status and PL3/4 Do Not Enter Status. There are two fitted series resistors R117 and R131, and protective diode D72 to opto-coupler U36-1. On failure, there is no current flow and hence, causes the output at PH1 to be a logic low to the CPU. Similarly, for Do Not Enter R118, R123, D71 and U36-2 are provided to output PH2.

A circuit is provided to ensure the cooler has not been inadvertently switched off until the cooler timing has been completed. When the key switch on the operator pod is deactivated, power to all circuits is shut down except for the cooler and the CPU. This runs a software programme which times out the cooler and shuts off its own power.

The mechanism is as follows:

With CB1 and the operator pod key switch to KEY2 On, power is supplied to K2, and hence enabling +24 V AUX. This, through D53 (via PL2/11) switches on the cooler contactor K3 and from this, its ancillary contact producing +24 V Switched. A path, RL3 N/C contact and D58, then provides a second route to the K3 coil to ensure that the cooler power is maintained, even when KEY2 or Emergency Off 1 or 2 are turned off. The CPU controls this switch off after the

timing cooling period by causing a positive pulse to PJ5 to TR8 and RL3 coil circuitry.

LED's indicating voltage present are also provided for +24 Mains ON and Interlock +24 V.

2.8.8 TP2-1006 Sheet 5 of 5 (Pod, Emergency Off and Mains Monitoring)

Note: See CCU Control Board Schematic TP2–1006 (5–5) on page 2.1-16

The *Mains Voltage Monitoring* is implemented by the use of a low voltage transformer, which is buffered with the scaled signal to the A/D of the CPU.

The transformer supplies mains from the output of K3 to the Mains Monitoring Board. The 7 V AC output from the transformer is supplied to the TP2 Control PCB (PL3/7 and PL3/8) and is scaled by R102 and R103. Buffer U27 provides a positive 2.5 V offset to PL3/8 (TP22) and ensures that the output of Buffer U24 is within the 0 V to 5 V range of the input signal PAD0 of the CPU A/D (TP7).

The pod buzzer is a ©Piezo-electric buzzer providing volume and pitch/ON-OFF options. The characteristics of the device are non-linear. The buzzer volume is controlled by a variable mark/space signal from the timer of the CPU output PP2. It is linked through an opto-isolator U35/1 to TR7, driving a two stage filter to U38/1 buffer, which provides a variable DC voltage source to the buzzer PL9/3. The pitch, pulse and ON-OFF control is managed by the second CPU timer PP3 in the CPU. This is linked through the opto-isolator U35/2 and TR9 to the other contact of the buzzer at PL9/3.

The serial connection through the pod to the operator PC (linked by an RS-232 null modem cable) is from the control CPU (PS0 and PS1). The connection is isolated from the CPU circuitry and the pod and operator PC. This is implemented by opto-isolators U30 and U34. Power to the RS-232 interface transmitter/receiver U33 is by a 5 V regulator U42 and is visually checked by the LED +5 VI. The switch chain EMERG OFF 1/EMERG OFF 2 and KEY2, enabling K2 is on PL6/2—Pl6/1 (from the room), PL9/1—PL9/2 and PL8/6—PL8/5 KEY2 (on the pod). The two chains are opto-isolated from end by the CPU at PM7 and PM3.

The operator pod controls *X-Ray ON*, *X-Ray OFF* and KEY3 switches are similarly opto-isolated and are fed to the CPU at PM0, PM1 and PM2. The operator pod indicators *X-Ray ON*, *X-Ray OFF*, and *HT ON* are driven by the opto-isolated transistor circuits PM4, PM5 and PM6 respectively. The AUX ON indicator is powered directly by +24 V AUX line.

2.8.9 Mains Monitoring Board PCB Circuit

Note: See TP2 Mains Monitor Board Schematic TP2–1015 on page 2.1-17

The *Mains Monitoring Board Schematic TP2-1015* contains the circuits for monitoring mains voltages. This separates mains voltages from the low voltage of the TP2 CPU PCB. It has two sections—the mains monitor transformer and the external warning lamps and monitoring circuits.

The TP2 has a mains monitor facility which provides monitoring of mains voltages to check for fault conditions (*for example*, brownouts, missed cycles, low voltages, etc.). The mains voltage is monitored from the cooler contactor (K3) output connected to the mains module PL2/1 and PL2/2.

The toroidal transformer is powered through fuse F1 (500 mA anti-surge) with a mains on neon indicator. The output of the transformer, which is nominally 7 VAC and supplied to the CCU control board by connector pins PL3/7 transformer, is nominally 7 VAC and supplied to the CCU control board by connector pins PL3/7 and PL3/8.

On the TP2 CCU control PCB, the input signal is scaled (by resistive dividers) and rectified and conditioned to be monitored by the CPU A/D. The signal is saved in the cyclic, which is buffered in the log and preserves 10 seconds of memory when an error occurs.

The warning lamps are powered from the AUX mains at PL2/3 and PL2/4 through fuse F2 (500 mA anti-surge) with a *Mains ON* neon indicator. The *Controlled Area* and *Do Not Enter* lamps are switched by current driven SSR switches (solid switch relays) SSR1 and SSR2 (zero crossing switches). The zero crossing switches and the monitoring components are fitted at live connections PL1/2 and PL1/3.

The bulbs (max 50 W) are connected between the neutral and switched live connections (PL1/2 and PL1/5 and PL1/3 and PL1/5). Opto-couplers provide isolators from the mains to monitor the current in the bulbs. Zener diodes (3V6, D3, D4) limit the current in the positive cycle of the mains and protection diodes D1, D2 and the negative cycle. Each opto-coupler output is low when the lamp is on and the timing components (R8, R6, C1 and R13, R5 and C2) smooth out the half wave of the mains. The transistors TR1 and TR2 indicate to the CCU control board when a lamp bulb is faulty or blown.

2.8.10 TP2 Temp and Dose Interface Board Circuit

Note: See TP2 Temp & Dose Board Schematic TP2–1007 on page 2.1-18

This PCB must be fitted in systems using ion chambers to measure dose. The PCB[1] provides an additional interface to a thermocouple for temperature measurement to allow the TP2 CCU control board to compensate.

From the TP2 CCU control board there is a screened cable to the X-Ray head connecting a temperature/dose interface PCB incorporating two separate circuits. One provides a thermocouple interface that senses the air temperature at the X-Ray dosimeter chamber and the second is a cable driver for the dosimeter electronics.

The thermocouple output (T type) signal is converted to a 1WIRE bus signal using device U2. This bus combines a signal and power line and a ground return. At the TP2 control PCB in the CCU control board, the 1WIRE signal is converted to RS-232 serial data for CPU processing. The dosimeter has an output signal at TTL levels (PL1/3) with its frequency dependent on dose level. The other connections on PL1 are power and control signals.

1. Not required for time based systems

The PCB is powered by a +12 V DC source supplied from the TP2 CPU PCB, which is passed onto the dosimeter (PL1/5). There is a 5 V regular IC3 and a cable driver (RS-485 driver) IC3 on the PCB. The output of this driver has termination resistors and protective transorbs. An LED is fitted to indicate that the 12 V supply is active.

2.9 Fuse Locations for the Xstrahl 200 (Floor Stand)

Note: In the event of a main circuit breaker fuse tripping, always investigate the cause of the fault prior to resetting the fuse.

2.9.1 Main Circuit Breaker Resettable MCB's (TP2 CCU)

The main circuit breaker resettable MCB's are located inside the TP2 CCU enclosure on the bottom of the inner door.

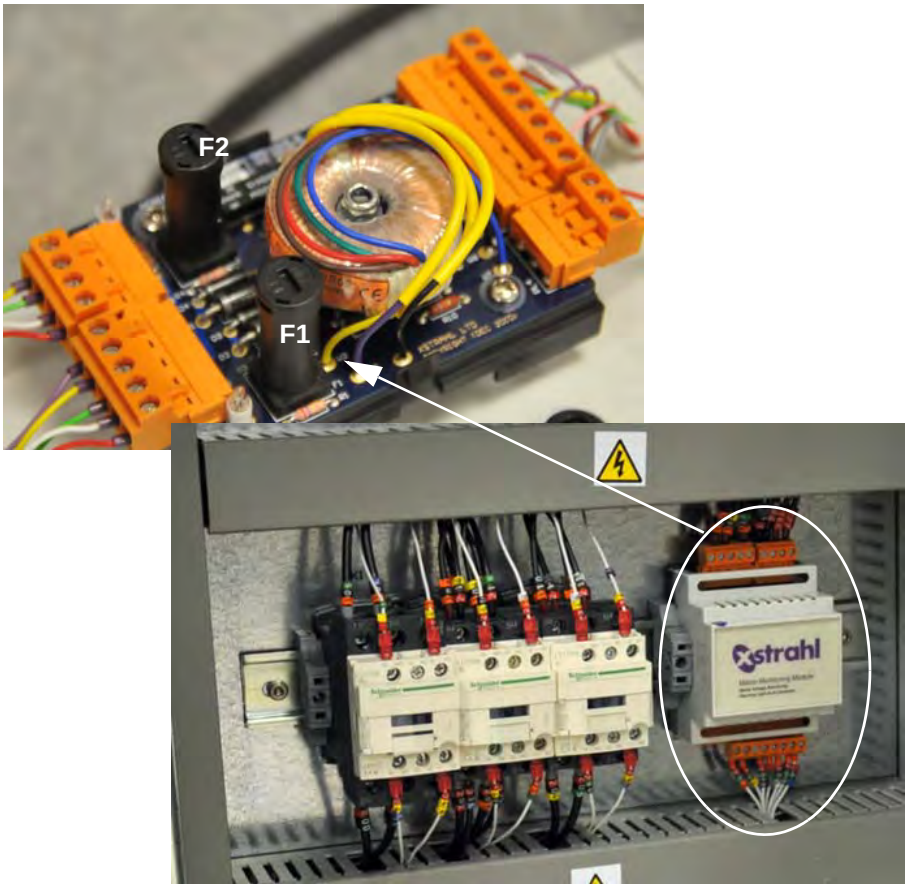
Figure 2–9: Locations of the Main Circuit Breaker Resettable MCB Fuses

Main Circuit Breaker Resettable MCB Fuses		
Fuse	**Fuse Value**	**Description**
CB1	32A (type C)	Generator mains power
CB2	6A (type C)	Generator auxiliary power Control board +24V supply
CB3	6A (type D)	Cooler mains power Interlock +24V supply
CB4	2A (type C)	Tube stand power

2.9.2 Mains Monitoring Module Fuses (TP2 CCU)

The mains monitoring module is located on the rear electrical panel of the TP2 CCU enclosure (below the inner door). F1 and F2 fuses are accessed by removing the cover of the mains monitoring module.

Figure 2–10: Location of the Mains Monitoring Module Fuses

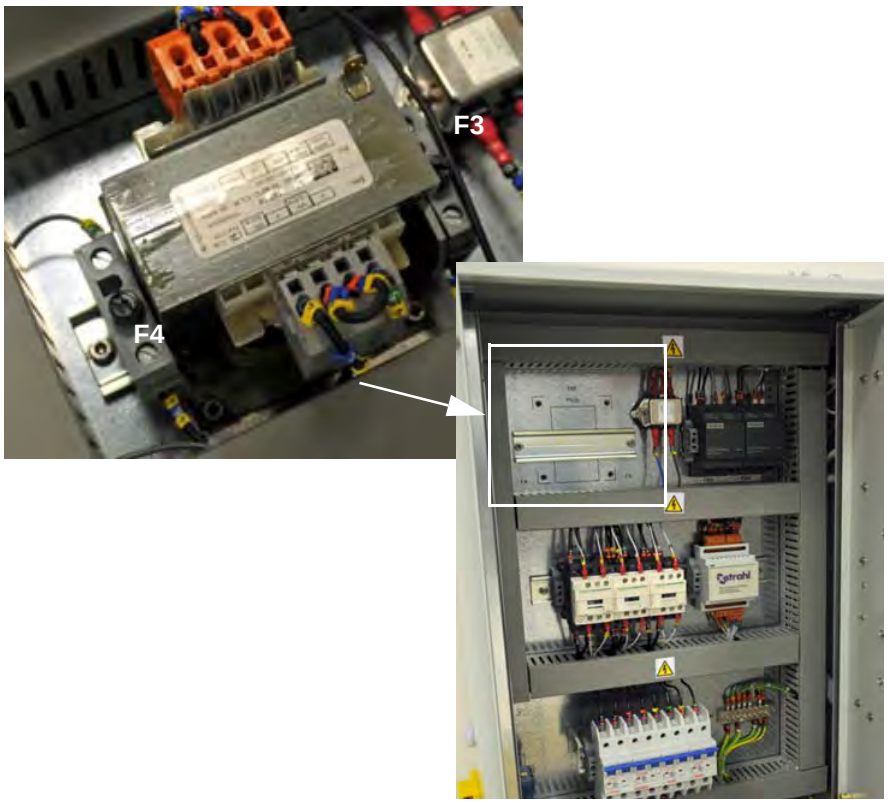


Mains Monitoring Module Fuses		
Fuse	**Fuse Value**	**Description**
F1	500 mA anti-surge (T) 20 mm fuse	Mains Monitoring Transformer
F2	500 mA anti-surge (T) 20 mm fuse	Safety Warning Lights

2.9.3 Tube Stand Fuses (TP2 CCU)

The tube stand fuses are located on the rear electrical panel of the TP2 CCU enclosure (below the inner door). F3 and F4 fuses are located adjacent to the tube stand transformer TX2.

Figure 2–11: Locations of Tube Stand Fuses



Tube Stand Fuses		
Fuse	**Fuse Value**	**Description**
F3	1.6A anti-surge (T) 20 mm fuse	Tube Stand Transformer (primary)
F4	4A fast (F) 20 mm fuse	Tube Stand Transformer (secondary)

2.10 Fuse Locations for the Xstrahl 200 (Ceiling Stand)

Note: In the event of a main circuit breaker fuse tripping, always investigate the cause of the fault prior to resetting the fuse.

2.10.1 Main Circuit Breaker Resettable MCB's (TP2 CCU)

The main circuit breaker resettable MCB's are located inside of the TP2 CCU enclosure on the inner door.

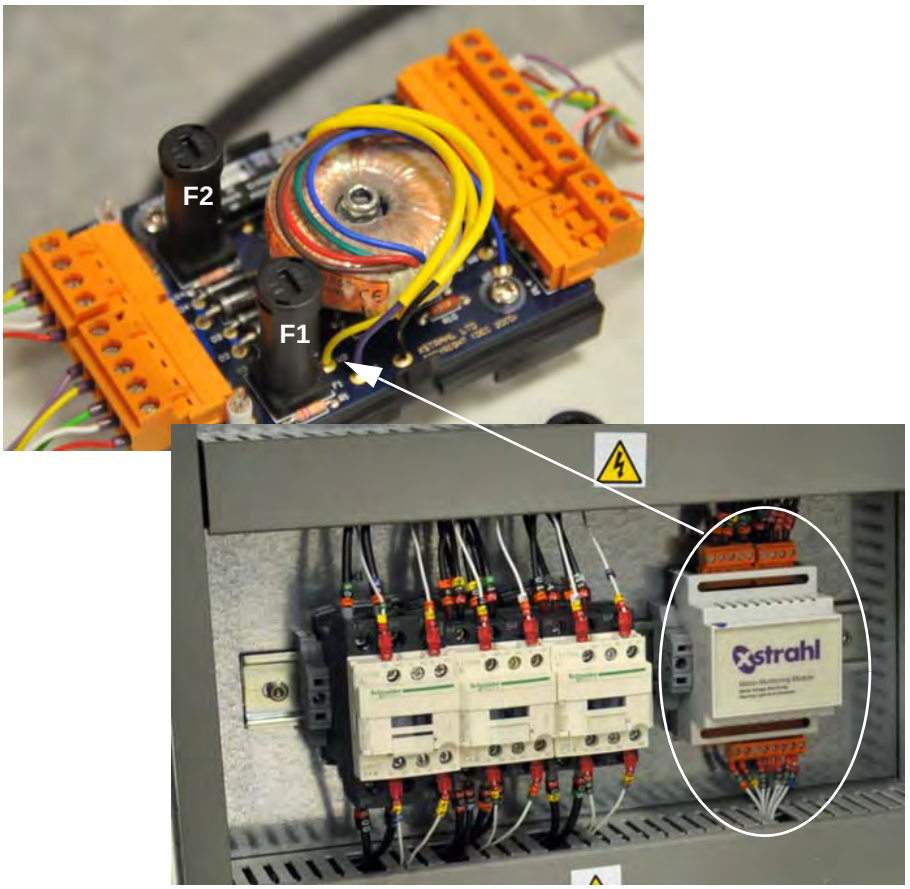
Figure 2–12: Location of the Main Circuit Breaker Resettable MCB Fuses

Main Circuit Breaker Resettable MCB Fuses		
Fuse	**Fuse Value**	**Description**
CB1	32A (type C)	Generator mains power
CB2	6A (type C)	Generator auxiliary power Control board +24V supply
CB3	6A (type D)	Cooler mains power Interlock +24V supply
CB4	2A (type C)	Tube stand power

2.10.2 Mains Monitoring Module Fuses (TP2 CCU)

The mains monitoring module is located on the rear electrical panel of the TP2 CCU enclosure (beneath the inner door). F1 and F2 fuses are accessed by removing the cover of the mains monitoring module.

Figure 2–13: Location of Mains Monitoring Module Fuses



Mains Monitoring Module Fuses (Ceiling Stand)		
Fuse	**Fuse Value**	**Description**
F1	500 mA anti-surge (T) 20 mm fuse	Mains Monitoring Transformer
F2	500 mA anti-surge (T) 20 mm fuse	Safety Warning Lights

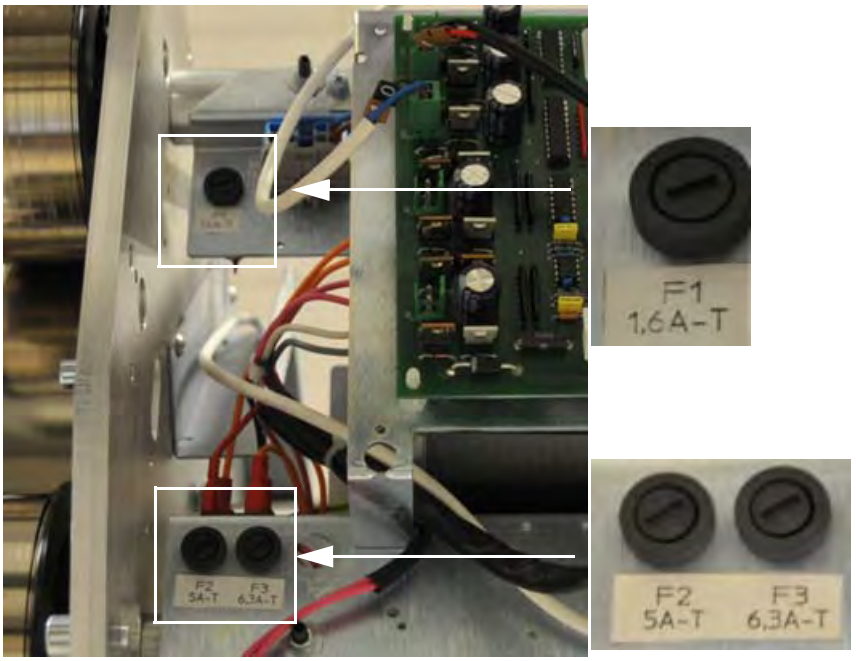
2.10.3 Tube Stand Fuses (Ceiling Stand)

The tube stand fuses are located beneath the cover of the ceiling stand.

To access the tube stand fuses:

1. Remove the ceiling stand cover. The fuses are located beneath the ceiling stand transformer.

Figure 2–14: Location of Tube Stand Fuses (Ceiling Stand)

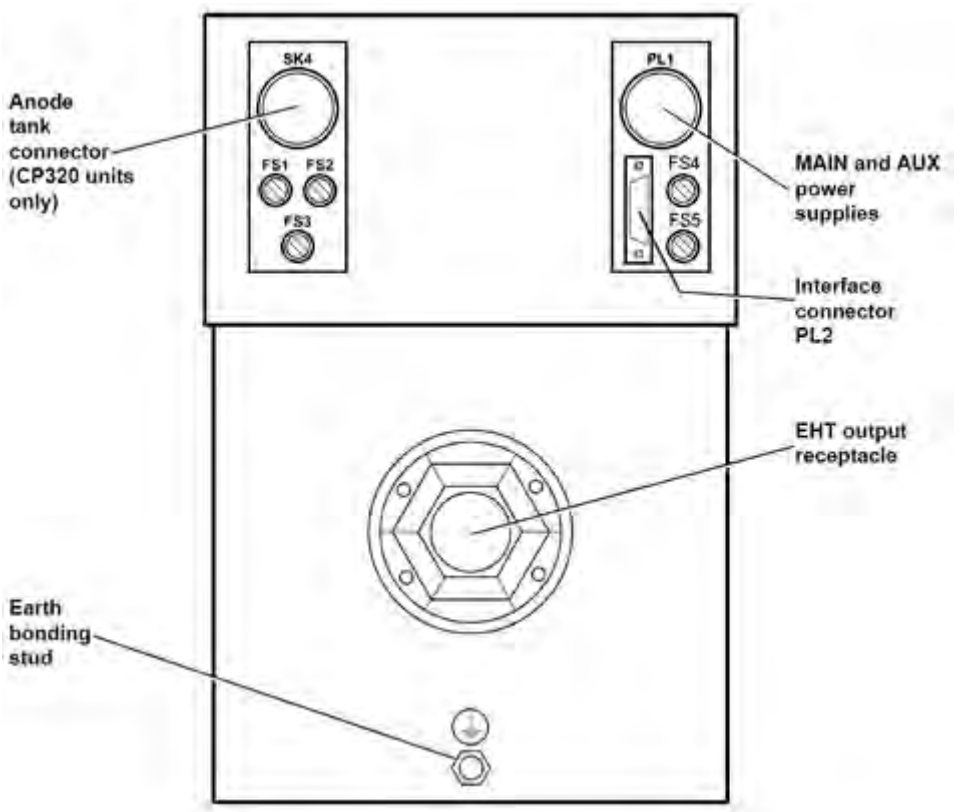


Tube Stand Fuses (Ceiling Stand)		
Fuse	**Fuse Value**	**Description**
F1	1.6A anti-surge (T) 32 mm fuse	Tube stand 230 VAC fuse
F2	5A anti-surge (T) 32 mm fuse	Tube stand fuse
F3	6.3A anti-surge (T) 32 mm fuse	Tube stand 24 VAC fuse

2.11 Generator Fuses (External)

The external generator fuses are located outside of the generator next to the power inlet cable.

Figure 2–15: Location of External Generator Fuses



Generator Fuses (External)		
Fuse	**Fuse Value**	**Description**
FS1	1A anti-surge (T) 20 mm fuse	Generator +18V supply (and control PCB +12V)
FS2		Generator -18V supply (and control PCB +12V)
FS4		Generator AUX power (L)
FS5		Generator AUX power (N)
FS3	5A fast (F) 20 mm fuse	Generator +30V supply (power for IGBT control and drive)

2.12 Generator Fuses (Internal)

The internal generator fuses are located inside the generator.

To access the internal generator fuses:

1. Remove the top cover of the Gulmay CP generator. The fuses are located on the Main Power In (after the mains filter).

Figure 2–16: Illustration of Generator Fuse (Internal)

Internal Generator Fuses		
Fuse	**Fuse Value**	**Description**
FS6	63A 240V BS88 Fast acting FF HRC power LET fuse (17.7 mm dia x 56 mm)	Generator main power
FS7	63A 240V BS88 Fast acting FF HRC power LET fuse (17.7 mm dia x 56 mm)	Generator main power

2.13 Spare Parts List

Recommended spare parts:

Spare Parts (Floor Stand)		
No.	**Description**	**Reference**
1	Silicon paste	HT cable grease
2	Warning light bulb BA15D 200/250V 10W	Room warning lights
3	500 mA anti-surge (T); 20 mm fuse	Mains monitoring module (F1, F2)
4	1.6A anti-surge (T); 20 mm fuse	TP2 tube stand transformer primary (F3)
5	4A fast (F); 20 mm fuse	TP2 tube stand transformer secondary (F4)
6	28V T 1.3/4 40 mA 10,000/hr bulb	Operator panel indicators
7	1 A anti-surge (T); 20 mm fuse	Generator (FS1, FS2, FS4, FS5)
8	5A fast (F); 20 mm fuse	Generator (FS3)
9	63A generator cartridge fuse	Generator
10	2.54 mm jumper	BDM programming link

Spare Parts (Ceiling Stand)		
No.	**Description**	**Reference**
1	Silicon paste	HT cable grease
2	Warning light bulb BA15D; 200/ 250V 10W	Room warning lights
3	500 mA anti-surge (T); 20 mm fuse	Mains monitoring module (F1, F2)
4	1.6 A anti-surge (T); 32 mm fuse	Ceiling stand (F1)
5	5A anti-surge (T); 32 mm fuse	Ceiling stand (F2)
6	6.3 A anti-surge (T); 32 mm fuse	Ceiling stand (F3)
7	28V T 1.3/4 40 mA 10,000/hr	Operator panel indicators
8	1A anti-surge (T); 20 mm fuse	Generator (FS1, FS2, FS4, FS5)
9	5A fast (F); 20 mm fuse	Generator (FS3)
10	63A generator cartridge fuse	Generator
11	2.54 mm jumper	BDM programming link

Section 2.1:

TP2 Control System Drawings

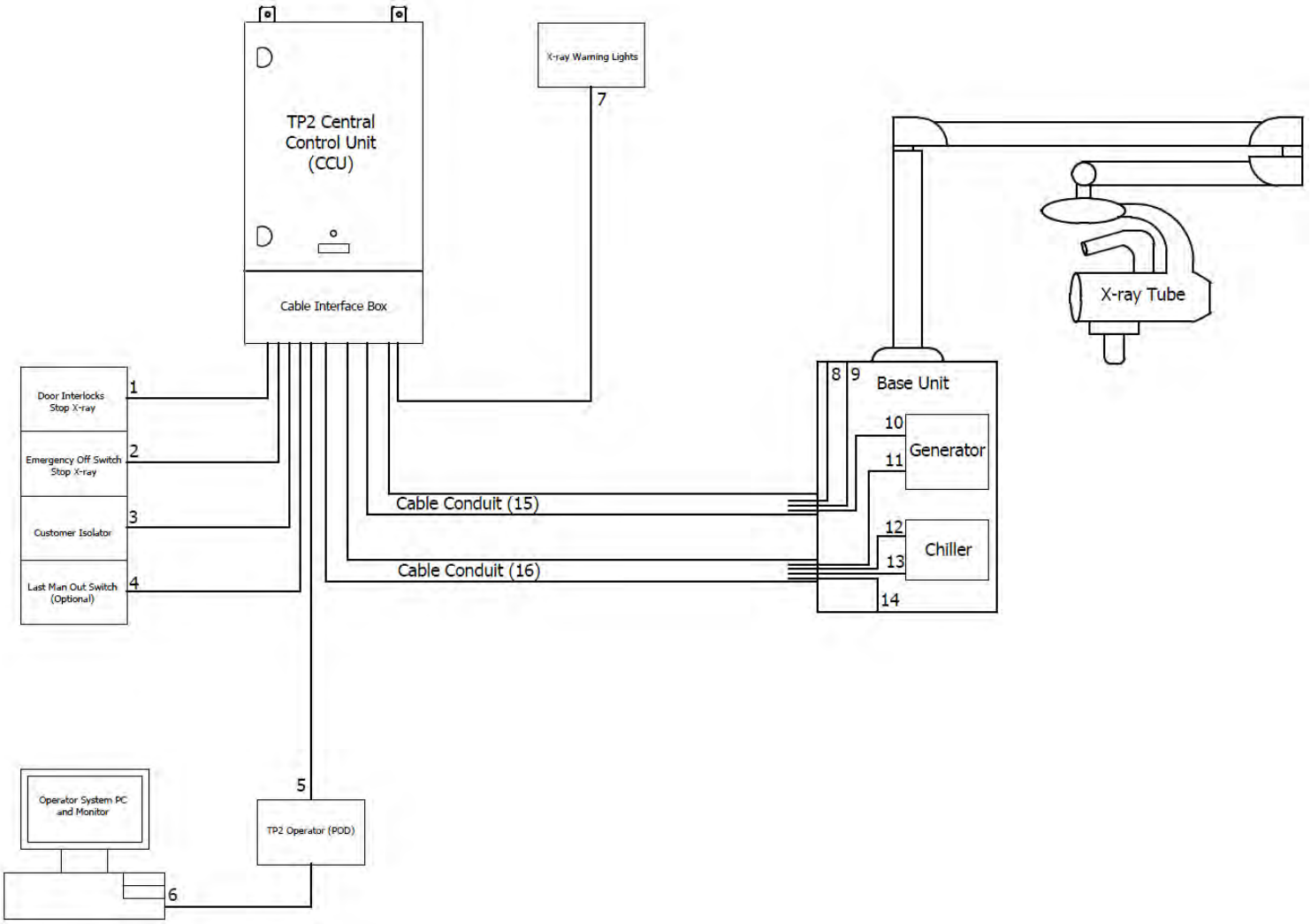
in this section

NOTE: This section provides circuit drawings which apply to all Xstrahl systems (100, 150, 200 and 300). If you are unsure of which drawing applies to your system, contact Xstrahl.

2.1 TP2 Control System Drawings

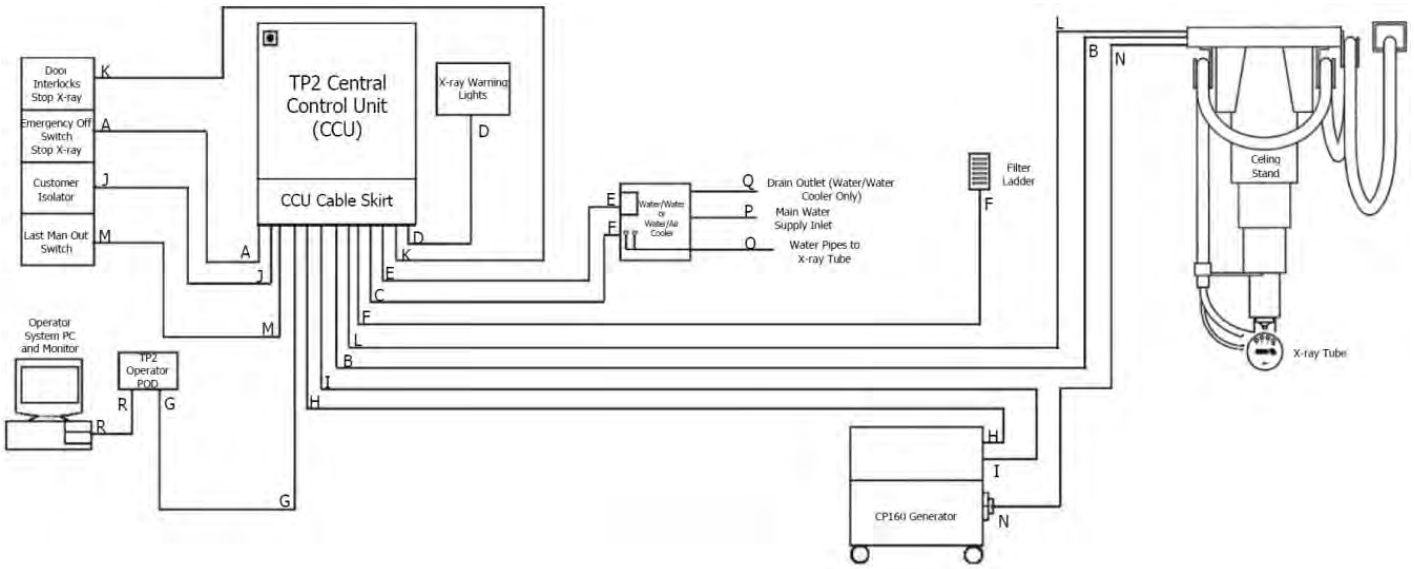
This section provides all of the required TP2 control system circuitry drawings. If you require further PDF's of any of these drawings in their entirety, please contact Xstrahl.

Drawing: A1—100 kV System (Base Unit)



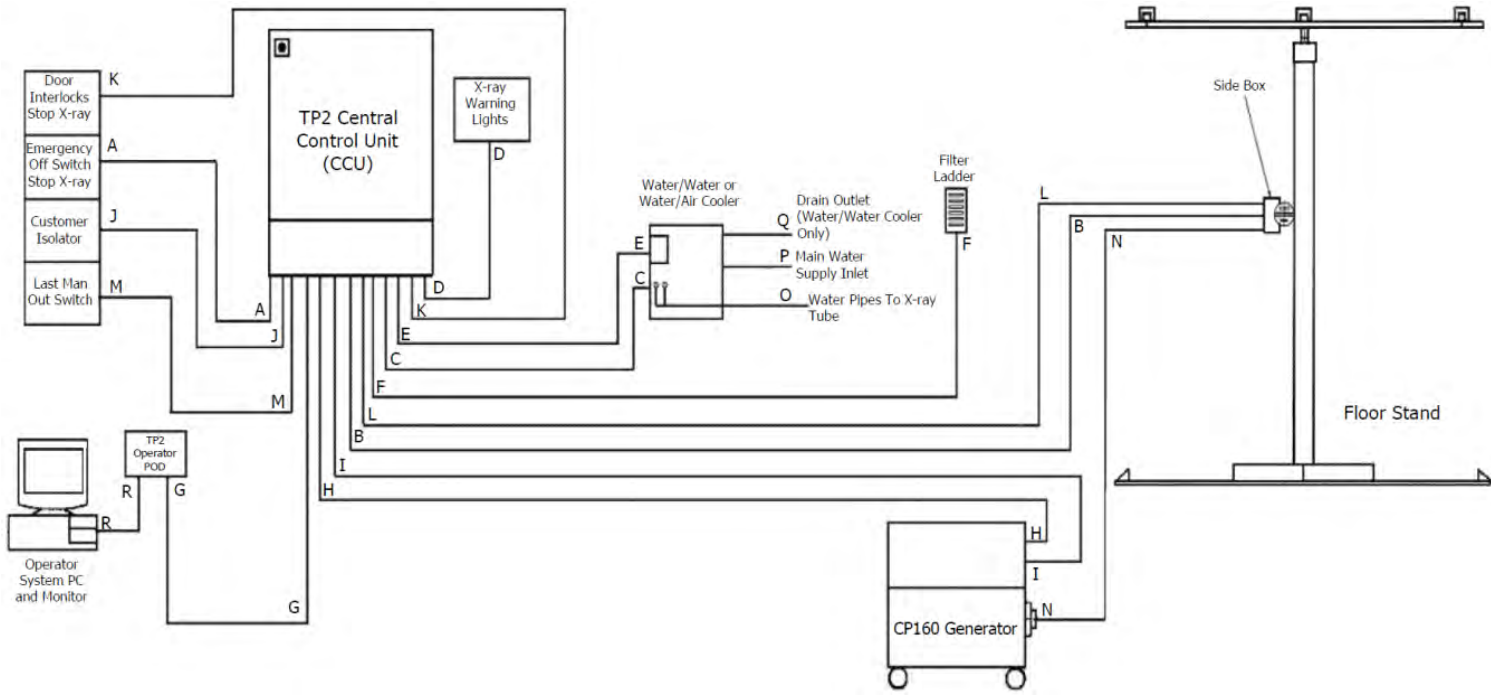
Cable Connection for 100 kV Base Unit			
No	**Description**	**From**	**To**
1	Door Interlocks Cable	TP2 CCU	Last Man Out Switch
2	Emergency Off Cable	TP2 CCU	Emergency Stop Switch
3	AC Mains In Cable	TP2 CCU	Supply Isolator
4	Last Man Out Switch Cable (Optional)	TP2 CCU	Last Man Out Switch
5	Pod Interface Cable	TP2 CCU	Operator Pod
6	RS-232	Operator Pod	PC
7	X-Ray Warning Lights Cable	TP2 CCU	Warning Lights
8	Tube Stand Power Cable	TP2 CCU	X-Ray Tube
9	Filters & Applicators Cable	TP2 CCU	X-Ray Tube
10	Generator Interface Cable	TP2 CCU	Generator
11	Generator Mains Cable	TP2 CCU	Generator
12	Chiller Interlocks Cable	TP2 CCU	Chiller
13	Chiller Power Cable	TP2 CCU	Chiller
14	Main Earth Cable	TP2 CCU	Base Unit Frame
15	Cable Conduit	TP2 CCU	Base Unit
16	Cable Conduit	TP2 CCU	Base Unit

Drawing: A2—150 kV System (Ceiling)



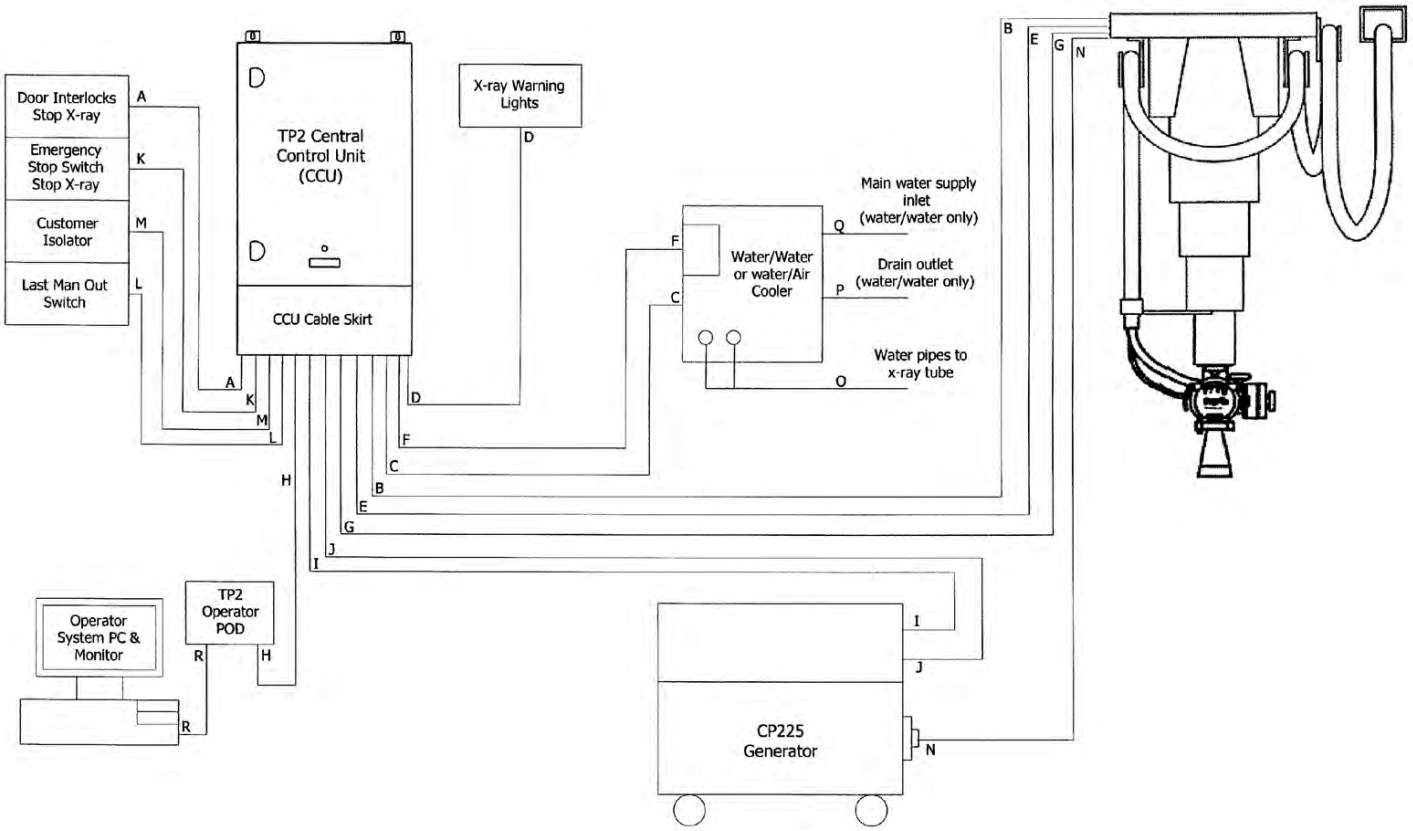
Cable Connection for 150 kV Ceiling Stand			
No	**Description**	**From**	**To**
A	Emergency Off Cable	TP2 CCU	Emergency Stop Switch
B	Tube Stand 230 V AC Cable	TP2 CCU	Ceiling Stand Carriage
C	Cooler Mains Cable	TP2 CCU	Cooler
D	X-Ray Warning Lights Cable	TP2 CCU	Warning Lights
E	Cooler Interlocks Cable	TP2 CCU	Cooler
F	Filters and Applicators Uncoded Cable	TP2 CCU	Filter Ladder
G	Pod Interface Cable	TP2 CCU	Operator Pod
H	Generator Interface Cable	TP2 CCU	Generator
I	Generator Mains Cable	TP2 CCU	Generator
J	AC Mains in Cable	TP2 CCU	Supply Isolator
K	Door Interlocks Cable	TP2 CCU	Door Switches
L	Filter in Place Cable	TP2 CCU	Ceiling Stand Carriage
M	Last Man Out Switch Cable (System Option)	TP2 CCU	Last Man Out Switch*
N	EHT Cable	Generator	X-Ray Tube
O	Cooler Hoses x 2 (AL 40)	Cooler	X-Ray Tube
P	Heat Exchanger Inlet (AL45)	Water Supply	Cooler Inlet
Q	Heat Exchanger Outlet (AL45)	Cooler Outlet	Drain
R	RS-232	Operator Pod	PC

Drawing: A3—150 kV System (Floor)



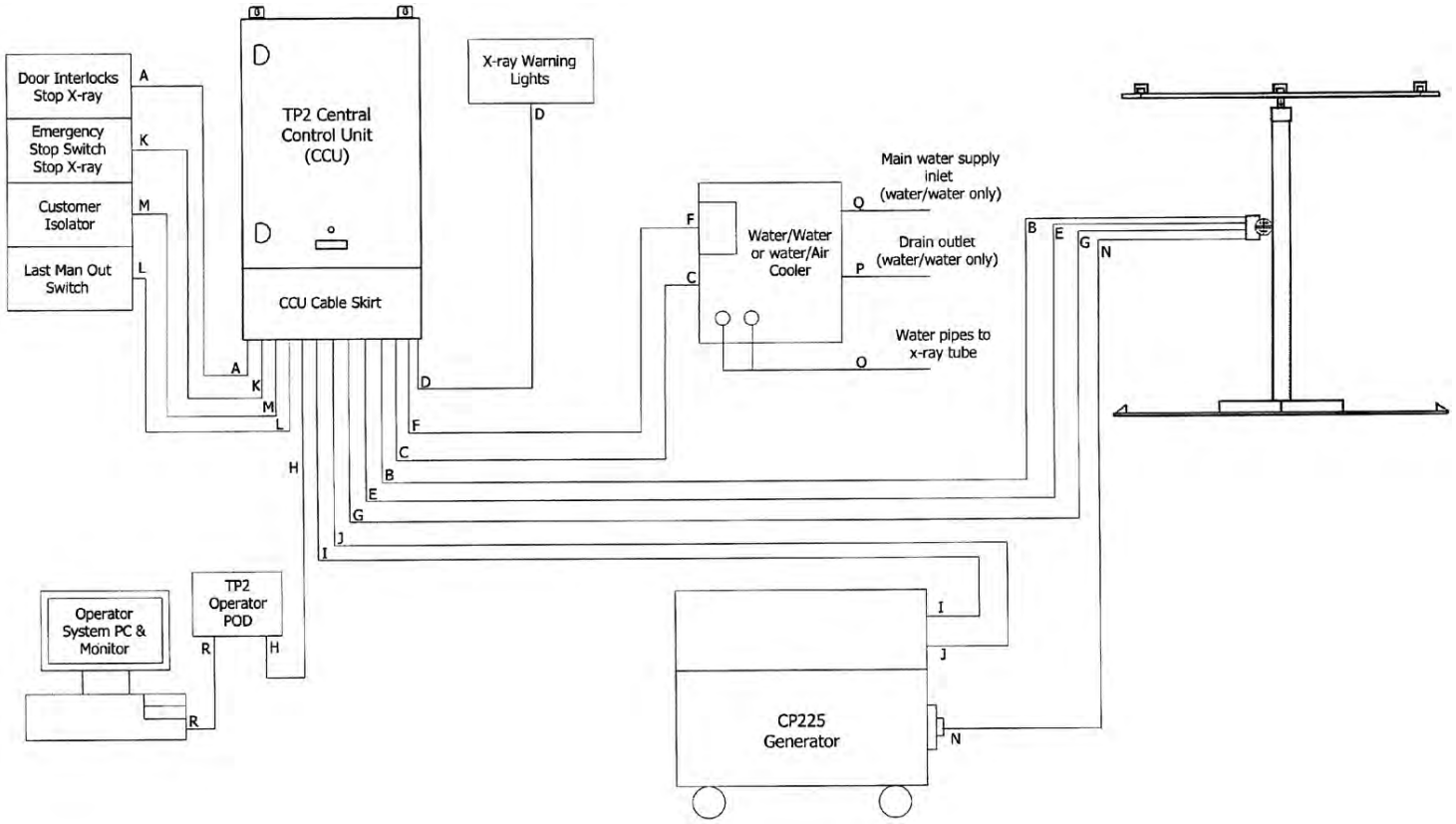
Cable Connection for 150 kV Floor Stand			
No	**Description**	**From**	**To**
A	Emergency Off Cable	TP2 CCU	Emergency Stop Switch
B	Tube Stand 24 V AC Cable	TP2 CCU	Floor Stand
C	Cooler Mains Cable	TP2 CCU	Cooler
D	X-Ray Warning Lights Cable	TP2 CCU	Warning Lights
E	Cooler Interlocks Cable	TP2 CCU	Cooler
F	Filters and Applicators Uncoded Cable	TP2 CCU	Filter Ladder
G	Pod Interface Cable	TP2 CCU	Operator Pod
H	Generator Interface Cable	TP2 CCU	Generator
I	Generator Mains Cable	TP2 CCU	Generator
J	AC Mains in Cable	TP2 CCU	Supply Isolator
K	Door Interlocks Cable	TP2 CCU	Door Switches
L	Filter in Place Cable	TP2 CCU	Floor Stand
M	Last Man Out Switch Cable (System Option)	TP2 CCU	Last Man Out Switch*
N	EHT Cable	Generator	X-Ray Tube
O	Cooler Hoses x 2 (AL 40)	Cooler	X-Ray Tube
P	Heat Exchanger Inlet (AL45)	Water Supply	Cooler Inlet
Q	Heat Exchanger Outlet (AL45)	Cooler Outlet	Drain
R	RS-232	Operator Pod	PC

Drawing: A4—200 kV System (Ceiling)



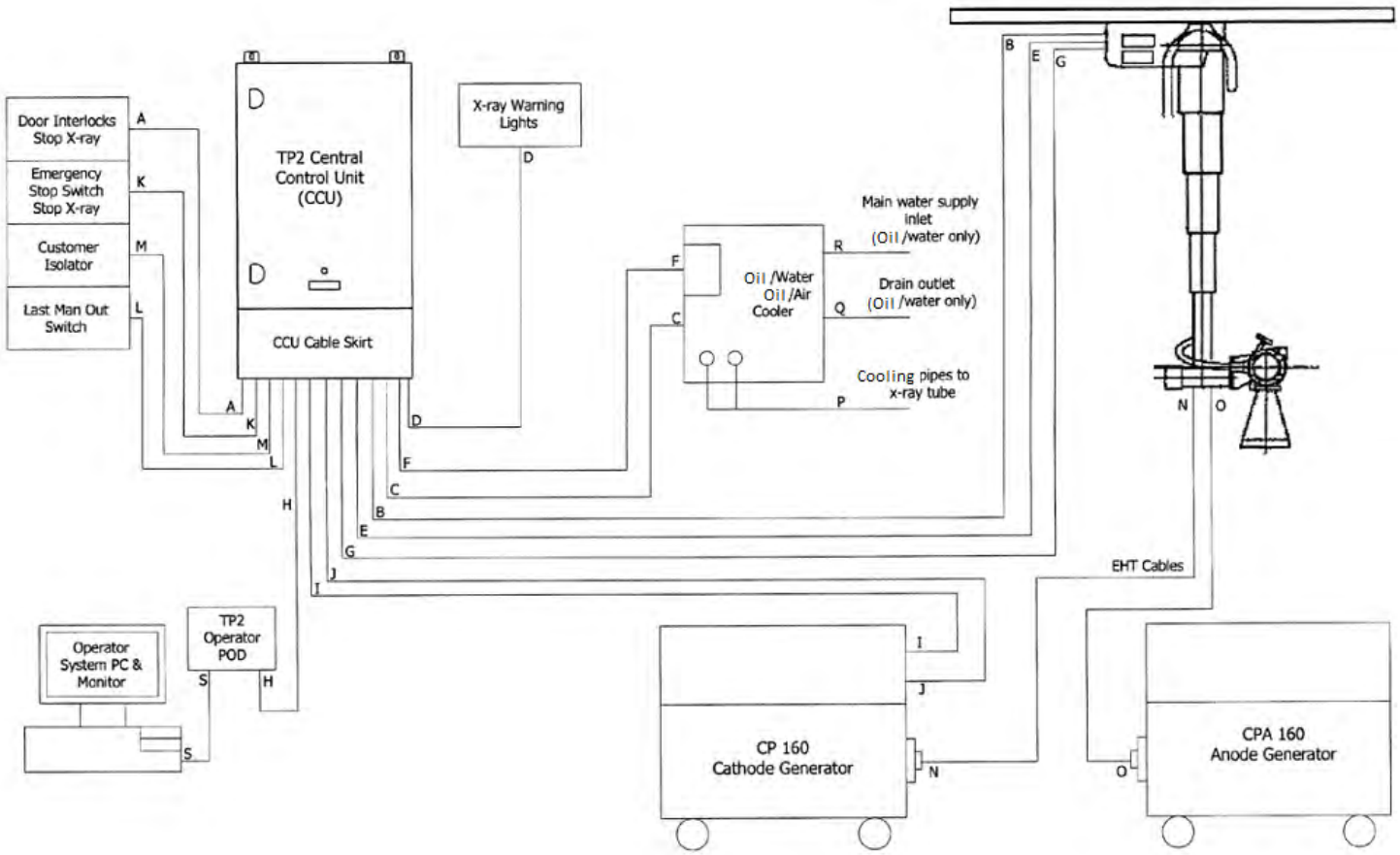
Cable Connection for 200 kV Ceiling Stand			
No	**Description**	**From**	**To**
A	Emergency Off Cable	TP2 CCU	Emergency Stop Switch
B	Tube Stand 230 V AC Cable	TP2 CCU	Ceiling Stand Carriage
C	Cooler Mains Cable	TP2 CCU	Cooler
D	X-Ray Warning Lights Cable	TP2 CCU	Warning Lights
E	Thermocouple & Dose Cable (Dose Based Systems Only)	TP2 CCU	Ceiling Stand Carriage
F	Cooler Interlocks Cable	TP2 CCU	Cooler
G	Filters & Applicators Coded Cable	TP2 CCU	Ceiling Stand Carriage
H	Pod Interface Cable	TP2 CCU	Operator Pod
I	Generator Interface Cable	TP2 CCU	Generator
J	Generator Mains Cable	TP2 CCU	Generator
K	AC Mains In Cable	TP2 CCU	Supply Isolator
L	Door Interlocks	TP2 CCU	Door Switches
M	Last Man Out Switch Cable (System Option)	TP2 CCU	Last Man Out Switch*
N	EHT Cable	Generator	X-Ray Tube
O	Cooler Hoses x 2 (AL 40)	Cooler	X-Ray Tube
P	Heat Exchanger Inlet (AL45) (Water to Water Cooler Only)	Water Supply	Cooler Inlet
Q	Heat Exchanger Outlet (AL45) (Water to Water Coolers Only)	Cooler Outlet	Drain
R	RS-232	Operator Pod	PC

Drawing: A5—200 kV System (Floor)



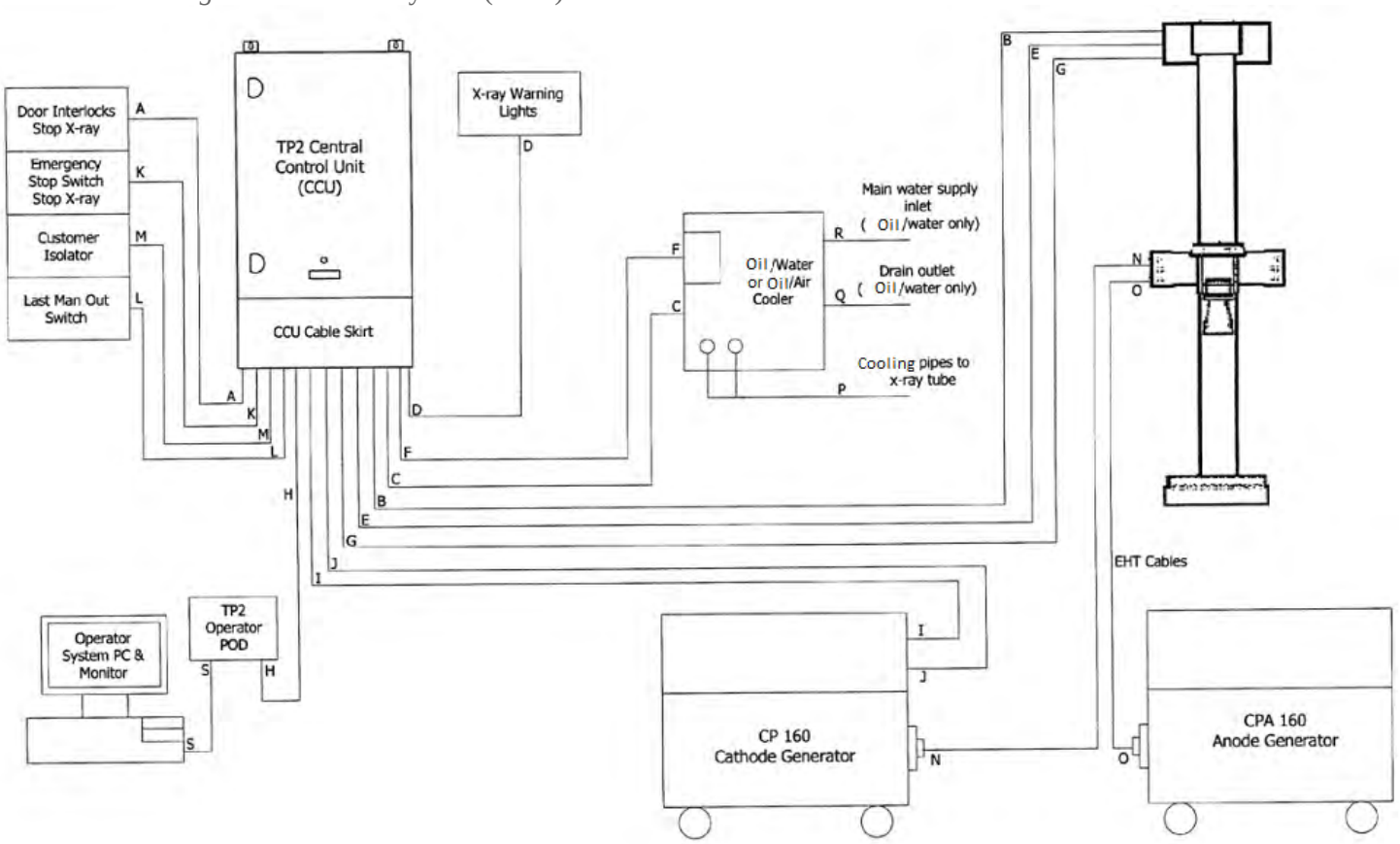
Cable Connection for 200 kV Floor Stand			
No	**Description**	**From**	**To**
A	Emergency Off Cable	TP2 CCU	Emergency Stop Switch
B	Tube Stand 24 V AC Cable	TP2 CCU	Ceiling Stand Carriage
C	Cooler Mains Cable	TP2 CCU	Cooler
D	X-Ray Warning Lights Cable	TP2 CCU	Warning Lights
E	Thermocouple & Dose Cable (Dose Based Systems Only)	TP2 CCU	Ceiling Stand Carriage
F	Cooler Interlocks Cable	TP2 CCU	Cooler
G	Filters & Applicators Coded Cable	TP2 CCU	Ceiling Stand Carriage
H	Pod Interface Cable	TP2 CCU	Operator Pod
I	Generator Interface Cable	TP2 CCU	Generator
J	Generator Mains Cable	TP2 CCU	Generator
K	AC Mains In Cable	TP2 CCU	Supply Isolator
L	Door Interlocks	TP2 CCU	Door Switches
M	Last Man Out Switch Cable (System Optional)*	TP2 CCU	Last Man Out Switch*
N	EHT Cable	Generator	X-Ray Tube
O	Cooler Hoses x 2 (AL 40)	Cooler	X-Ray Tube
P	Heat Exchanger Inlet (AL45) (Water to Water Cooler Only)	Water Supply	Cooler Inlet
Q	Heat Exchanger Outlet (AL45) (Water to Water Coolers Only)	Cooler Outlet	Drain
R	RS-232	Operator Pod	PC

Drawing: A6—300 kV System (Ceiling)



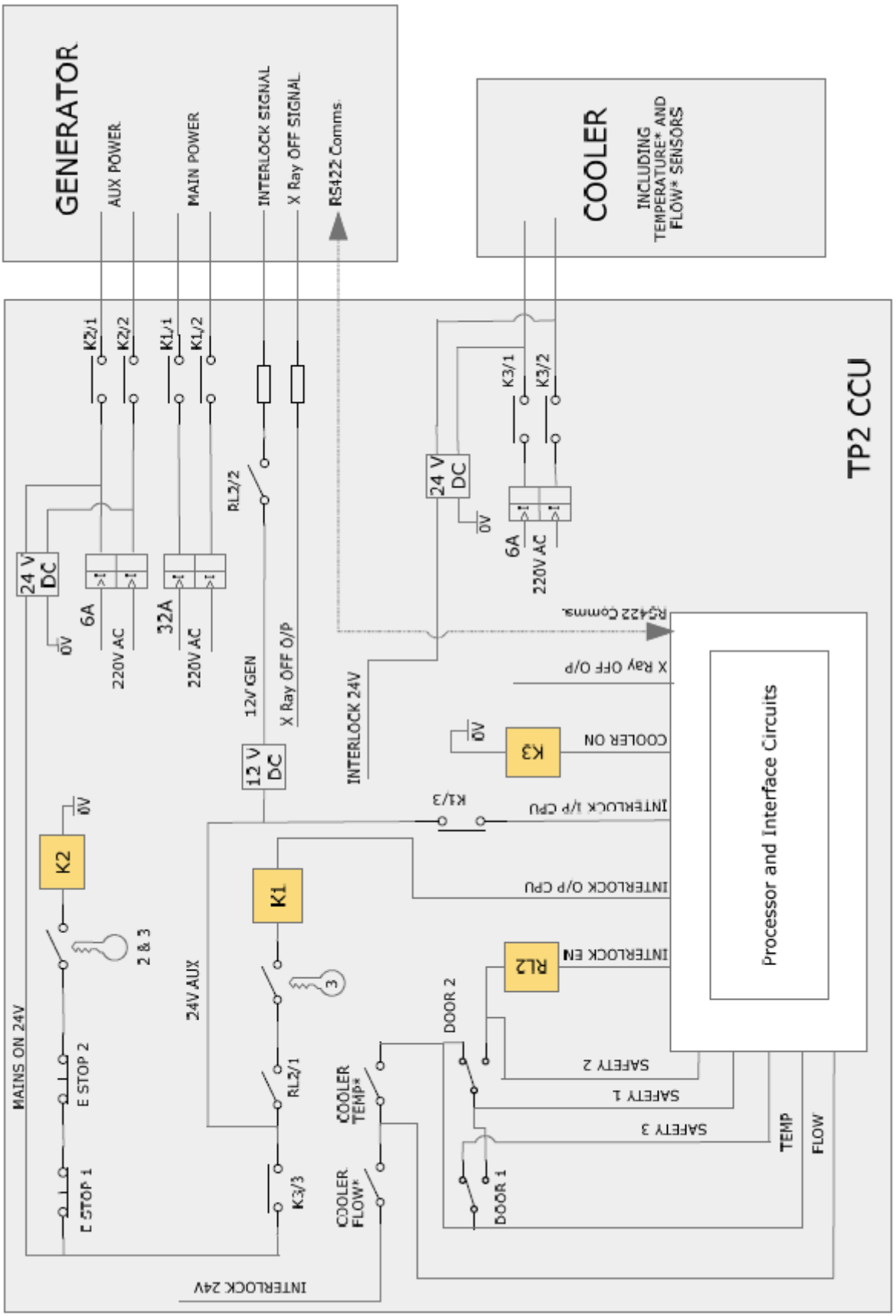
Cable Connection for 300 kV Ceiling Stand			
No	**Description**	**From**	**To**
A	Emergency Off Cable	TP2 CCU	Emergency Stop Switch
B	Tube Stand 230 V AC Cable	TP2 CCU	Ceiling Stand Carriage
C	Cooler Mains Cable	TP2 CCU	Cooler
D	X-Ray Warning Lights Cable	TP2 CCU	Warning Lights
E	Thermocouple & Dose Cable (Dose Based Systems Only)	TP2 CCU	Ceiling Stand Carriage
F	Cooler Interlocks Cable	TP2 CCU	Cooler
G	Filters & Applicators Coded Cable	TP2 CCU	Ceiling Stand Carriage
H	Pod Interface Cable	TP2 CCU	Operator Pod
I	Generator Interface Cable	TP2 CCU	Generator
J	Generator Mains Cable	TP2 CCU	Generator
K	AC Mains In Cable	TP2 CCU	Supply Isolator
L	Door Interlocks	TP2 CCU	Door Switches
M	Last Man Out Switch Cable (System Optional)*	TP2 CCU	Last Man Out Switch*
N	EHT Cable 1	Generator	X-Ray Tube
O	EHT Cable 2	Generator	X-Ray Tube
P	Cooler Hoses x 2 (AL 40)	Cooler	X-Ray Tube
Q	Heat Exchanger Inlet (AL45) (Oil to Water Coolers only)	Water Supply	Cooler Inlet
R	Heat Exchanger Outlet (AL 45) (Oil to Water Coolers only)	Cooler Outlet	Drain
S	RS-232	Operator Pod	PC

Drawing: A7—300 kV System (Floor)

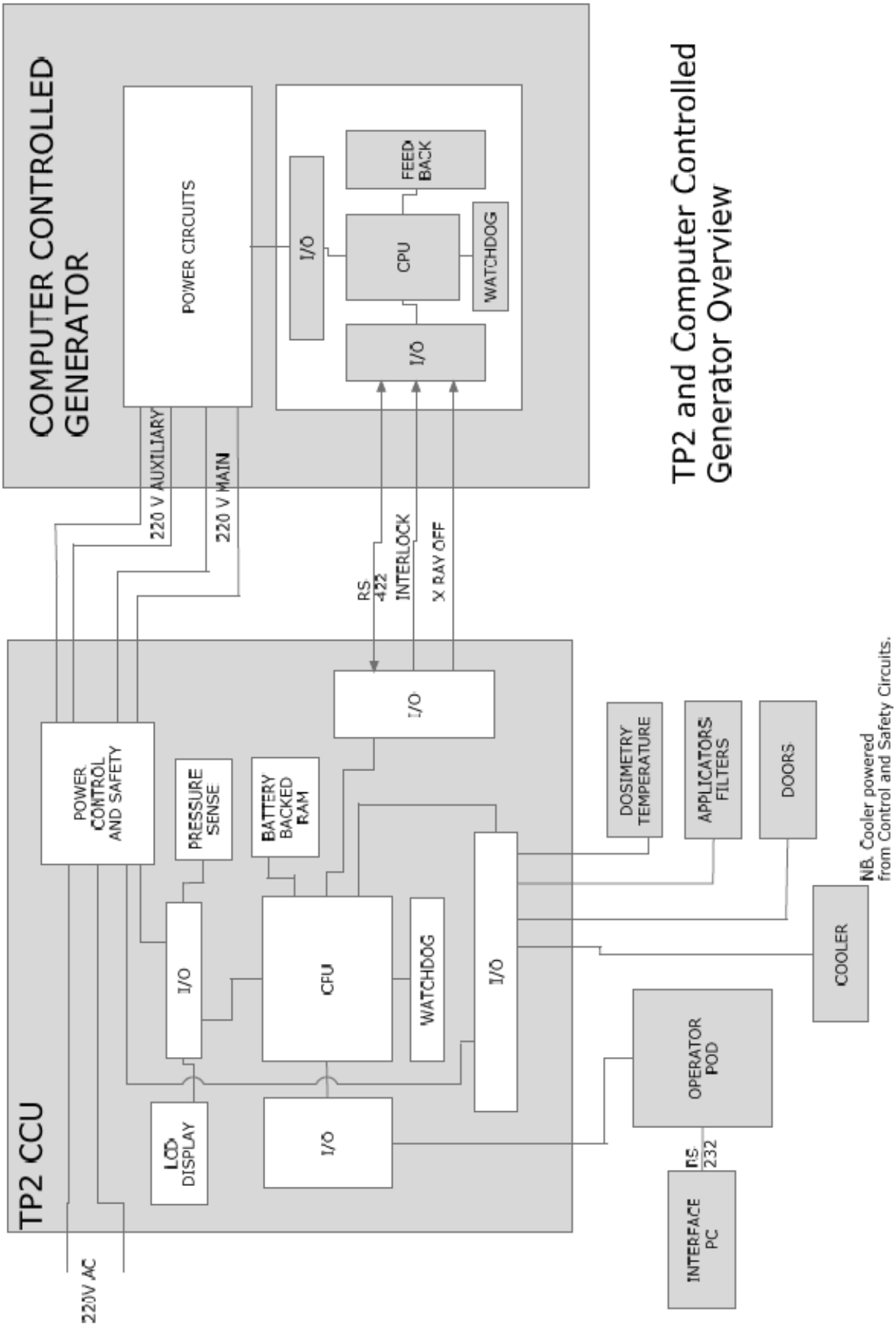


Cable Connection for 300 kV Floor Stand			
No	**Description**	**From**	**To**
A	Emergency Off Cable	TP2 CCU	Emergency Stop Switch
B	Tube Stand 230 V AC Cable	TP2 CCU	Ceiling Stand Carriage
C	Cooler Mains Cable	TP2 CCU	Cooler
D	X-Ray Warning Lights Cable	TP2 CCU	Warning Lights
E	Thermocouple & Dose Cable (Dose Based Systems Only)	TP2 CCU	Ceiling Stand Carriage
F	Cooler Interlocks Cable	TP2 CCU	Cooler
G	Filters & Applicators Coded Cable	TP2 CCU	Ceiling Stand Carriage
H	Pod Interface Cable	TP2 CCU	Operator Pod
I	Generator Interface Cable	TP2 CCU	Generator
J	Generator Mains In Cable	TP2 CCU	Generator
K	AC Mains In Cable	TP2 CCU	Supply Isolator
L	Door Interlocks	TP2 CCU	Door Switches
M	Last Man Out Switch Cable (System Optional)*	TP2 CCU	Last Man Out Switch
N	EHT Cable 1	Generator	X-Ray Tube
O	EHT Cable 2	Generator	X-Ray Tube
P	Cooler Hoses x 2 (AL 40)	Cooler	X-Ray Tube
Q	Heat Exchanger Inlet (AL45) (Oil to Water Coolers only)	Water Supply	Cooler Inlet
R	Heat Exchanger Outlet (AL 45) (Oil to Water Coolers only)	Cooler Outlet	Drain
S	RS-232	Operator Pod	PC

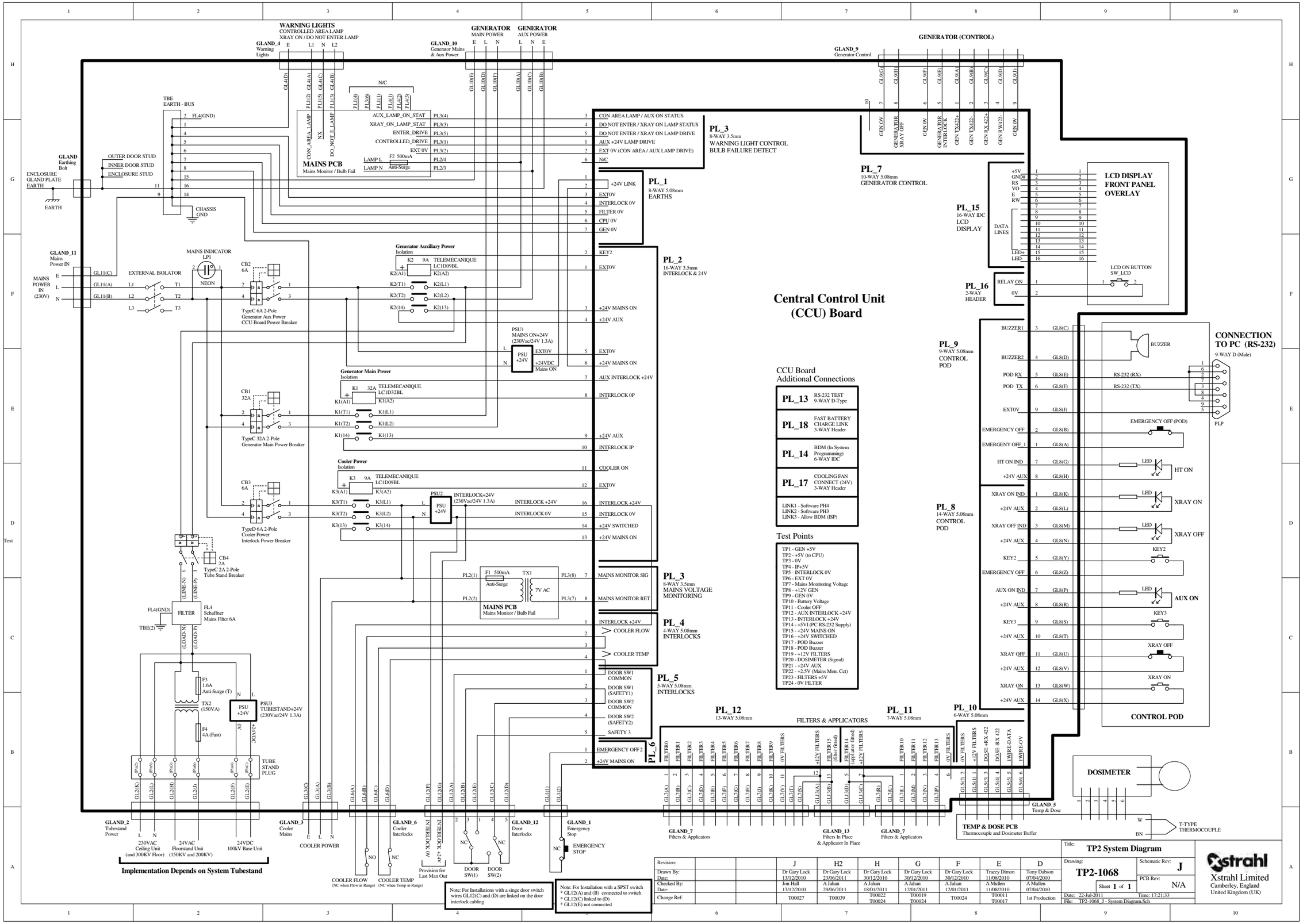
Drawing: B1—TP2 Safety System Overview



Drawing: B2—TP2 Safety System (Computer Controlled Gen)



Drawing: TP2 System Diagram TP2–1068



Revision:			J	H2	H	G	F	E	D
Drawn By:			Dr Gary Lock	Dr Gary Lock	Dr Gary Lock	Dr Gary Lock	Dr Gary Lock	Tracey Dimon	Tony Dabson
Date:			13/12/2010	23/06/2011	30/12/2010	30/12/2010	30/12/2010	11/08/2010	07/04/2010
Checked By:			Jon Hall	A Jahan	A Jahan	A Jahan	A Jahan	A Mullen	A Mullen
Date:			13/12/2010	29/06/2011	18/01/2011	12/01/2011	12/01/2011	11/08/2010	07/04/2010
Change Ref:			T00027	T00039	T00022 T00024	T00019 T00024	T00024	T00011 T00017	1st Production

Title: **TP2 System Diagram**
Drawing: **TP2-1068**
Schematic Rev: **J**
PCB Rev: **N/A**
Sheet **1** of **1**
Date: 22-Jul-2011 Time: 17:21:33
File: TP2-1068_J - System Diagram.Sch

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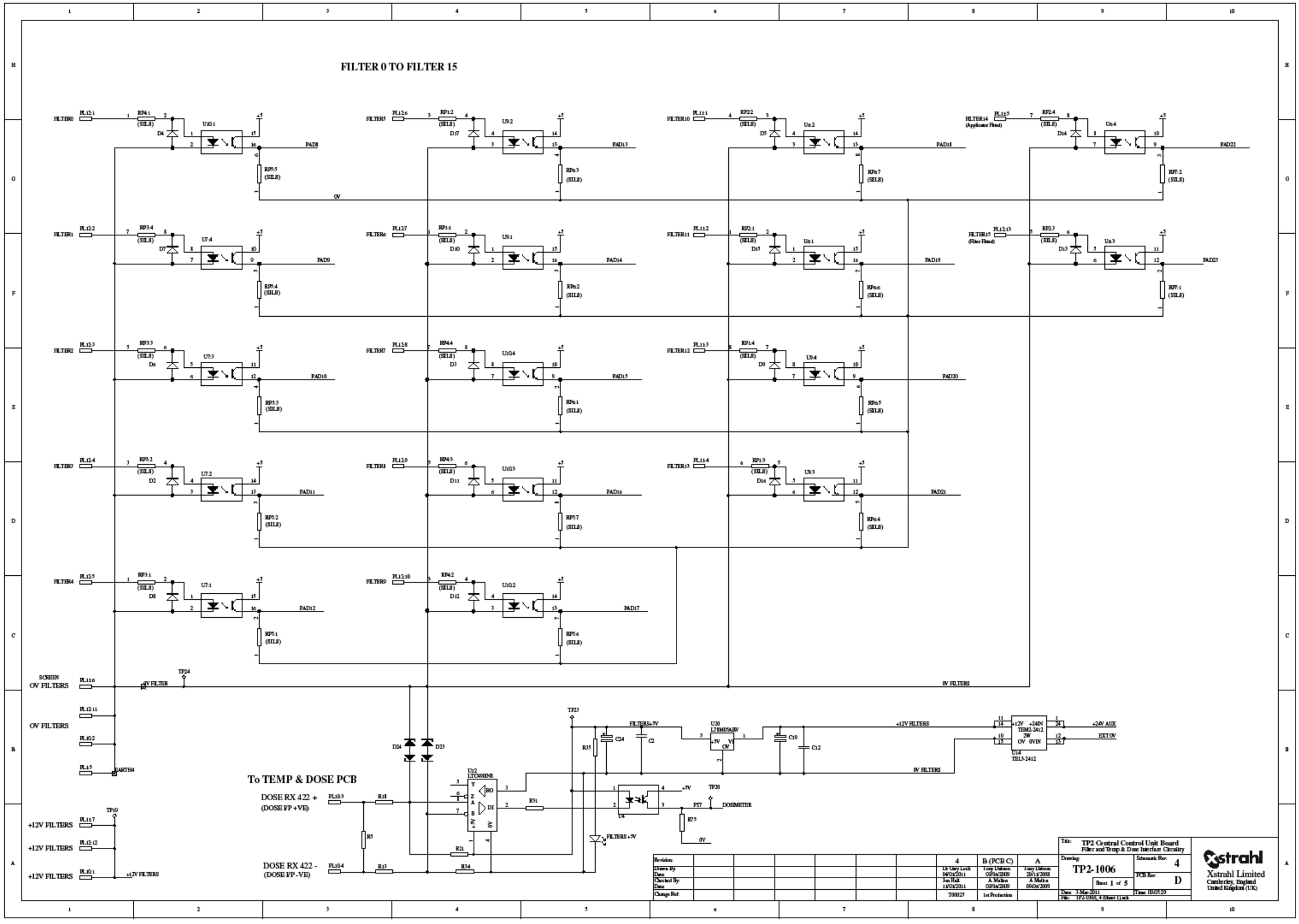
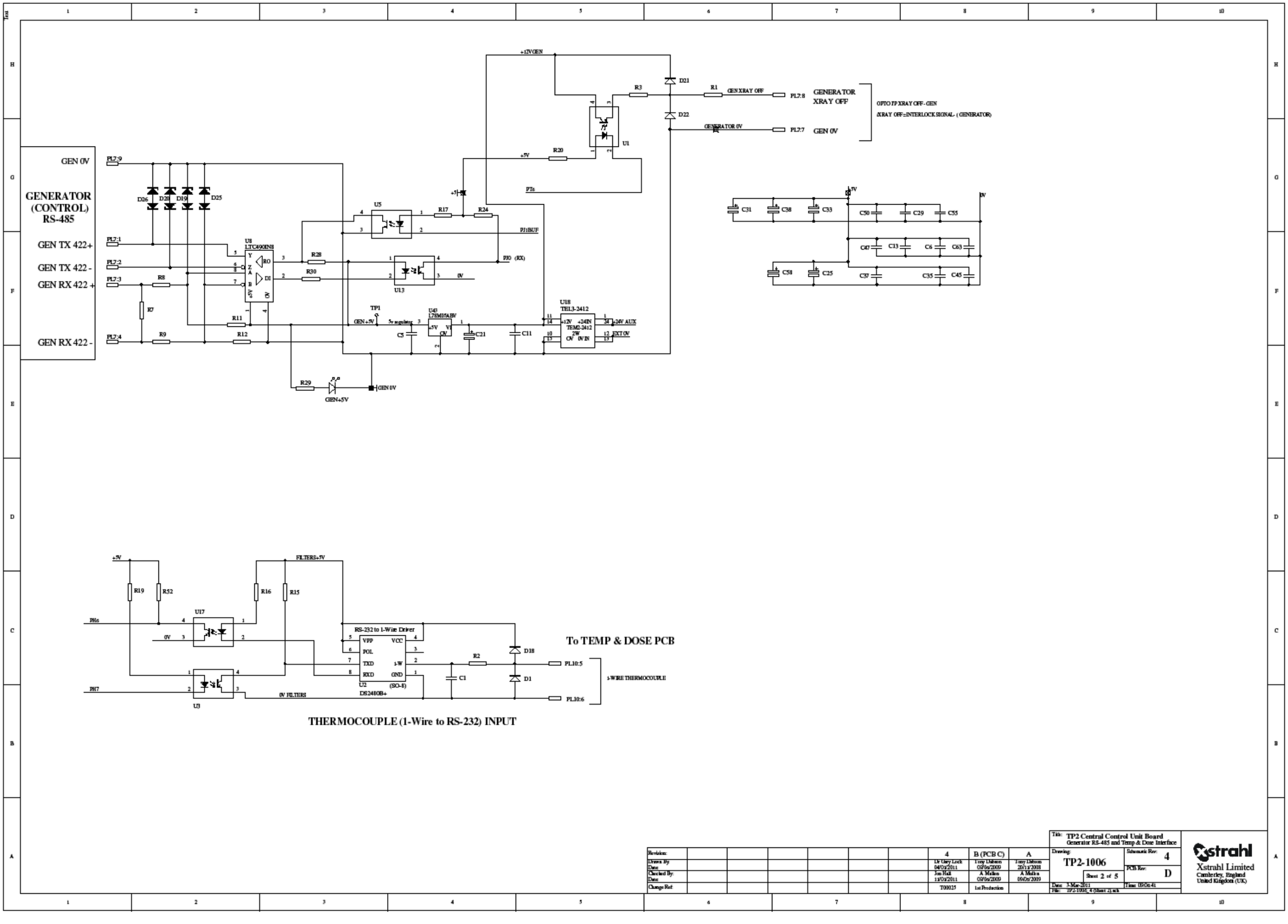
Camberley, England
United Kingdom (UK)

Drawing: CCU Control Board Schematic TP2–1006 (1–5)



Drawing: CCU Control Board Schematic TP2–1006 (2–5)



THERMOCOUPLE (1-Wire to RS-232) INPUT

								4	B (PCB C)	A
Revision:										
Drawn By:								Dr Gary Lock	Tony Dobson	Tony Dobson
Date:								04/03/2011	09/06/2009	20/11/2008
Checked By:								Jon Hall	A Mellon	A Mellon
Date:								13/03/2011	09/06/2009	09/06/2009
Change Ref:								T00025	1st Production	

Title: TP2 Central Control Unit Board
Generator RS-485 and Temp & Dose Interface

Drawing: TP2-1006 Sheet 2 of 5

Schematic Rev: 4
PCB Rev: D

Date: 3-Mar-2011 Time: 09:06:41
File: TP2-1006_4-5Sheet 2].sch

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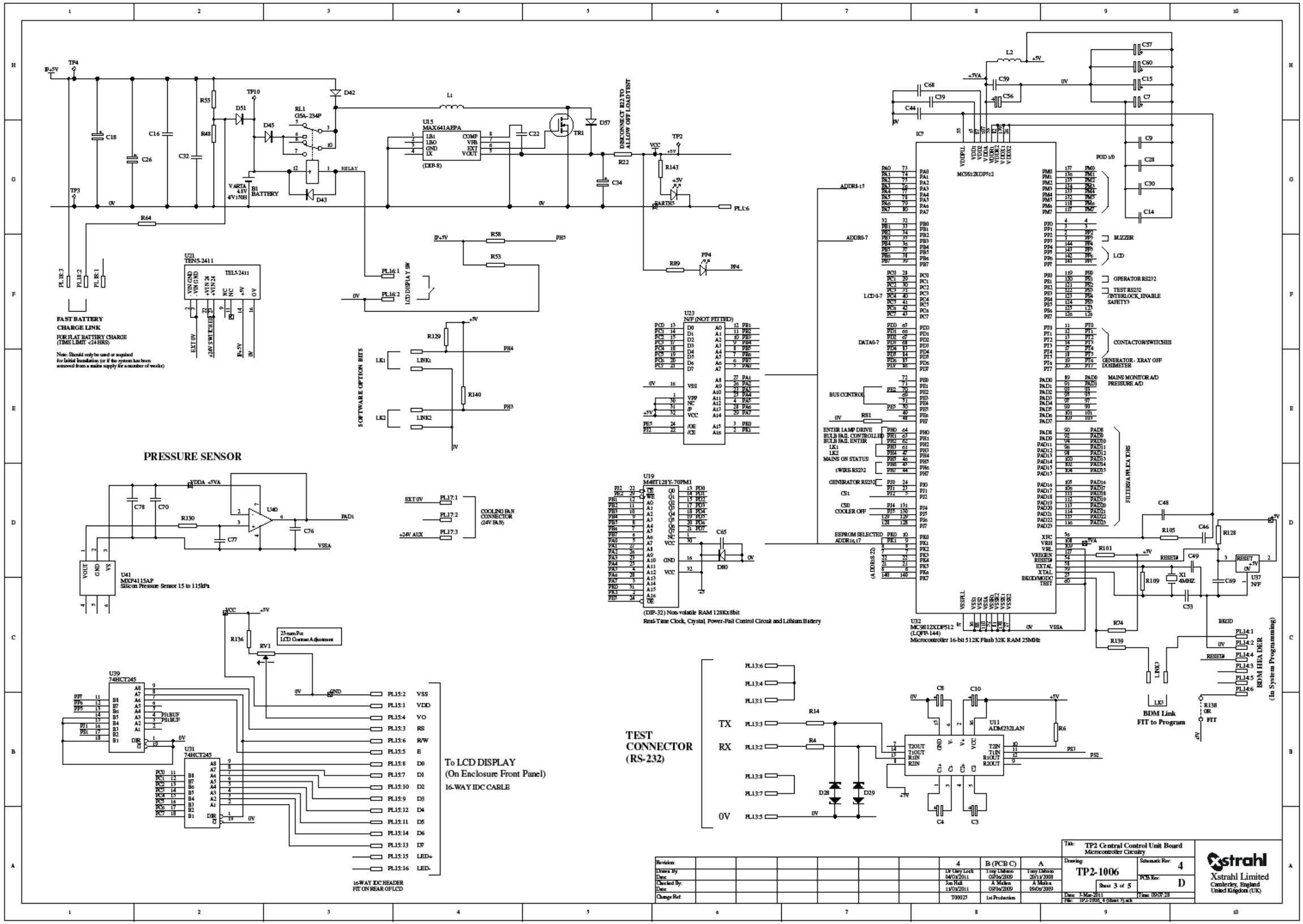
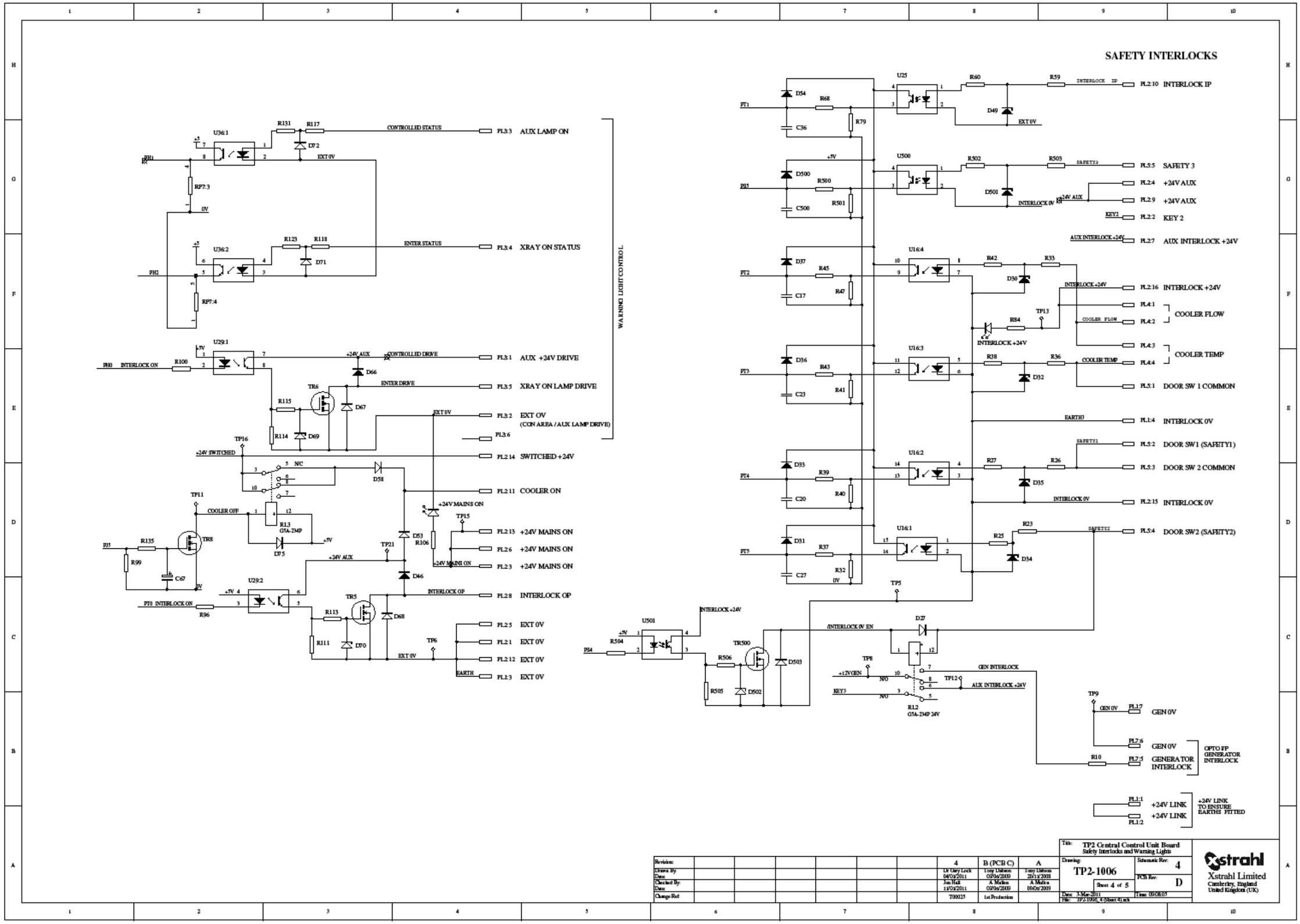
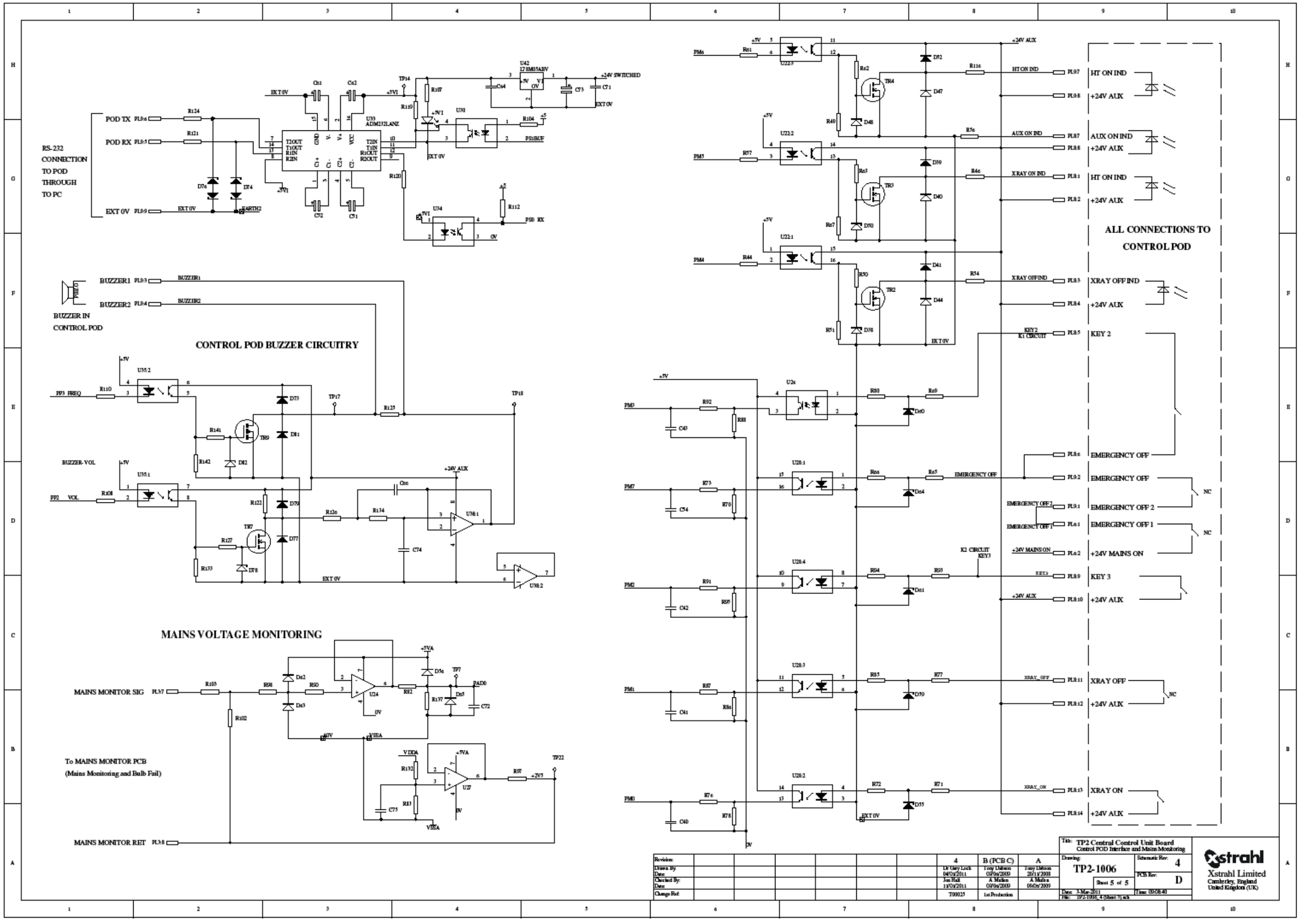
Drawing: CCU Control Board Schematic TP2–1006 (3–5)



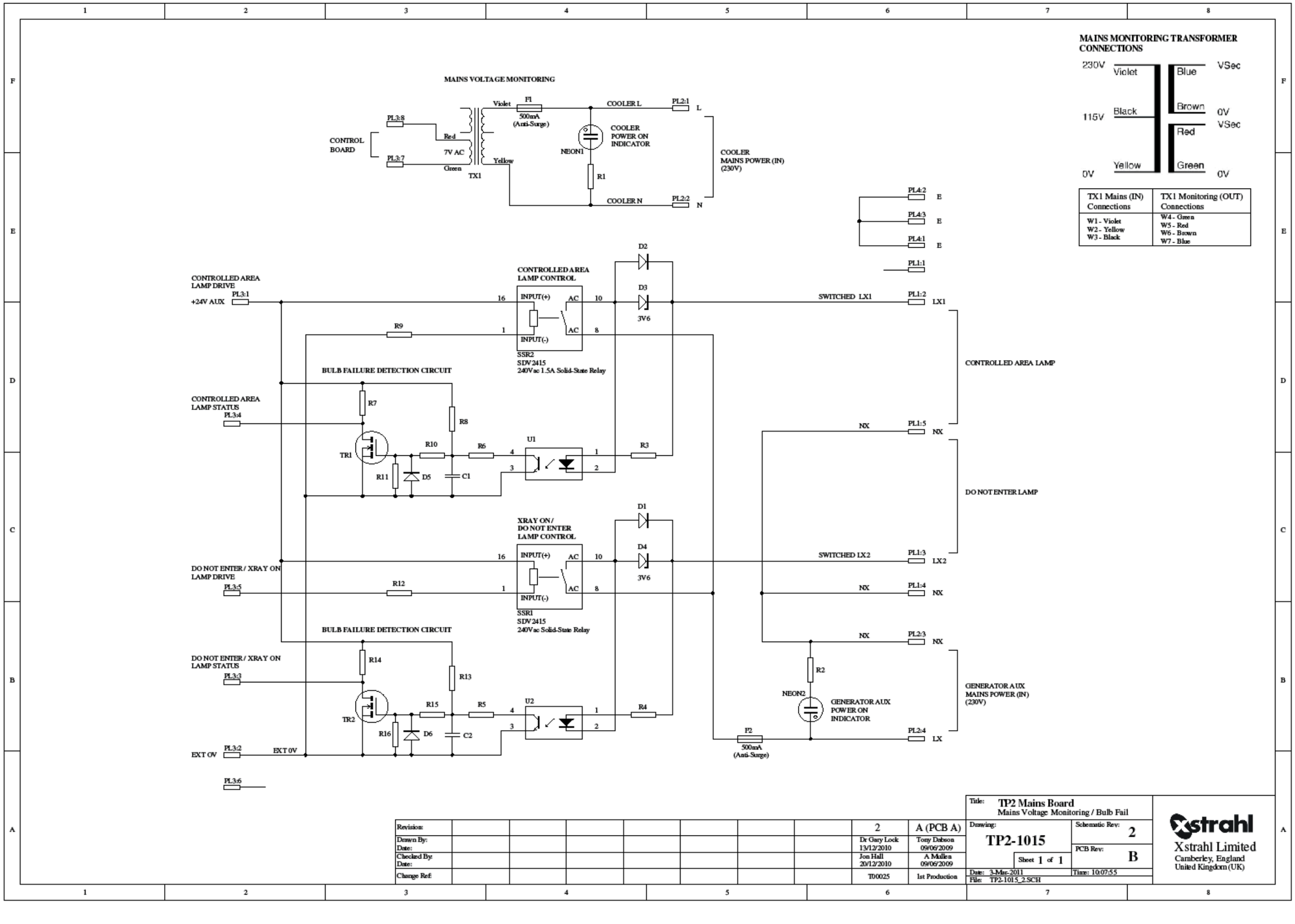
Drawing: CCU Control Board Schematic TP2–1006 (4–5)



Drawing: CCU Control Board Schematic TP2–1006 (5–5)



Drawing: TP2 Mains Monitor Board Schematic TP2–1015



Revision:								2	A (PCB A)	
Drawn By:								Dr Gary Lock	Tony Dobson	
Date:								13/12/2010	09/06/2009	
Checked By:								Jon Hall	A Mullen	
Date:								20/12/2010	09/06/2009	
Change Ref:								T00025	1st Production	

Title: **TP2 Mains Board**
Mains Voltage Monitoring / Bulb Fail

Drawing: **TP2-1015**

Schematic Rev: **2**

PCB Rev: **B**

Sheet 1 of 1

Date: 3-Mar-2011 Time: 10:07:55

File: TP2-1015_2.SCH

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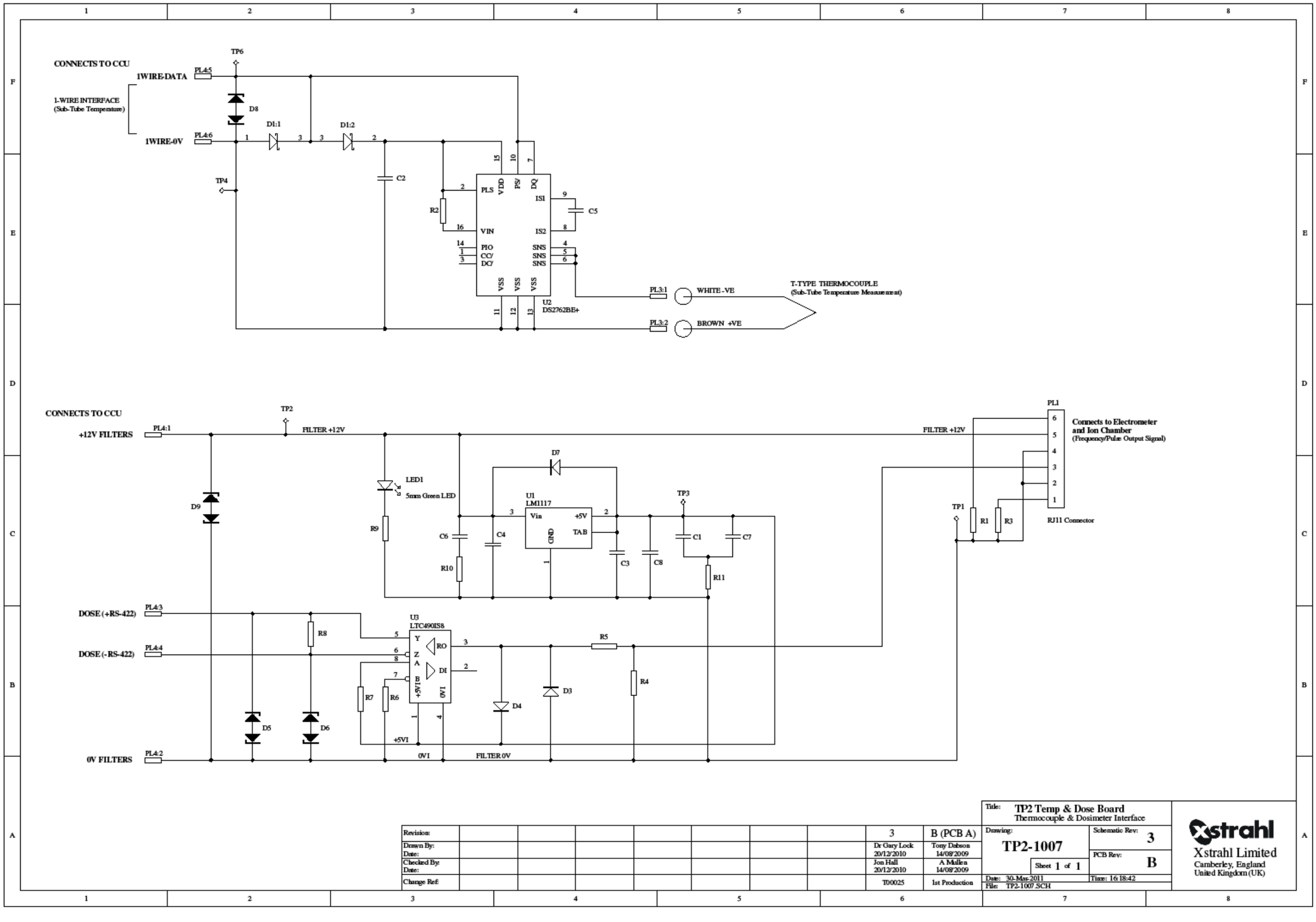
United Kingdom (UK)

Drawing: TP2 Temp & Dose Board Schematic TP2–1007



Revision:								3	B (PCB A)
Drawn By:								Dr Gary Lock	Tony Dobson
Date:								20/12/2010	14/08/2009
Checked By:								Jon Hall	A Mullen
Date:								20/12/2010	14/08/2009
Change Ref:								TD0025	1st Production

Title: **TP2 Temp & Dose Board**
Thermocouple & Dosimeter Interface

Drawing: **TP2-1007**

Sheet 1 of 1

Schematic Rev: 3

PCB Rev: B

Date: 30-Mar-2011 Time: 16:18:42

File: TP2-1007.SCH

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Section 3:

Fisica

in this section

3 Fisica

This section will guide you through all of the functions within the Fisica interface.

3.1 Overview

Fisica is the interface application enabling configuration of the TP2 controller and peripherals. It is also used to calibrate the treatment exposures for clinical use (dose systems).

Note: The treatment screens in the Xstrahl 100 are in time or minutes. Xstrahl produces both time (Xstrahl 100, 150 200 and 300) and dose based systems (Xstrahl 200 and 300). Dose based systems (Xstrahl 200 and 300) use MU in their treatment screens.

3.1.1 TP2 Peripherals

Fisica configures the following peripherals through the TP2 CCU (microprocessor based) controller:

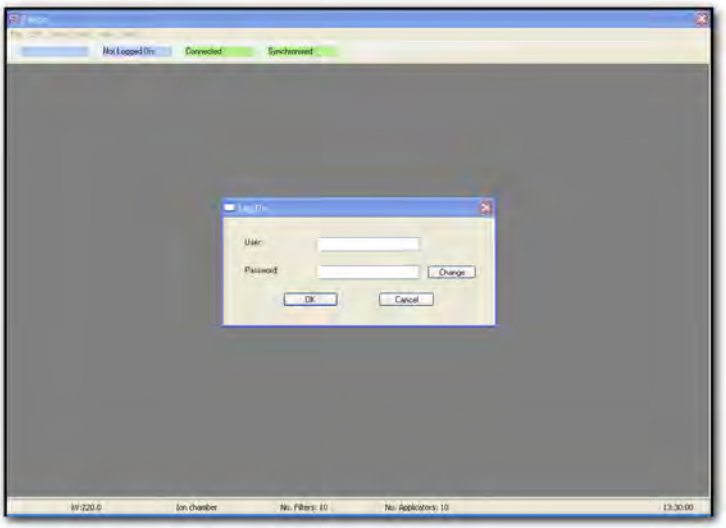
- PC
- Operator pod
- Generator
- Cooler
- Filter and applicator assembly
- Dose measurement
- Temperature measurement

3.1.2 System Parameters

System parameters are defined in databases stored on the PC. Fisica edits and downloads these parameters to the TP2 CCU.

3.1.3 Logging on to Fisica

Figure 3–1: Fisica Home



A user password and a required level of authority is necessary to access Fisica's calibration and control functions. For more information on logging on to Fisica, See section 3.2.19.

To log on to Fisica, double click the Fisica icon  on the desktop.

3.1.4 Communication

Fisica communicates to the TP2 CCU through the RS232 cable and automatically checks the status of the RS232 communications when the application is first launched on the PC.

If the communication between Fisica and the TP2 is successfully established, the Home screen is displayed and the information status bar (at the top of the screen) will indicate the systems are now connected.

Figure 3–2: Information Status Bar (Connected)

3.1.5 Connection Problems

If the TP2 isn't powered on communication cannot be established and a communication problem message will appear. The information status bar will display *Not Connected.*

Figure 3–3: Can't Open Serial Comms Message

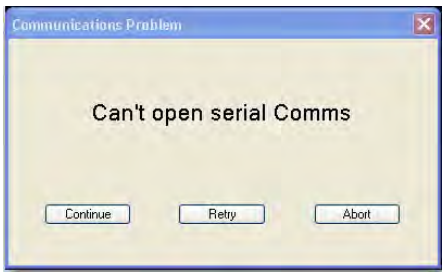


Figure 3–4: Information Status Bar (Not Connected)

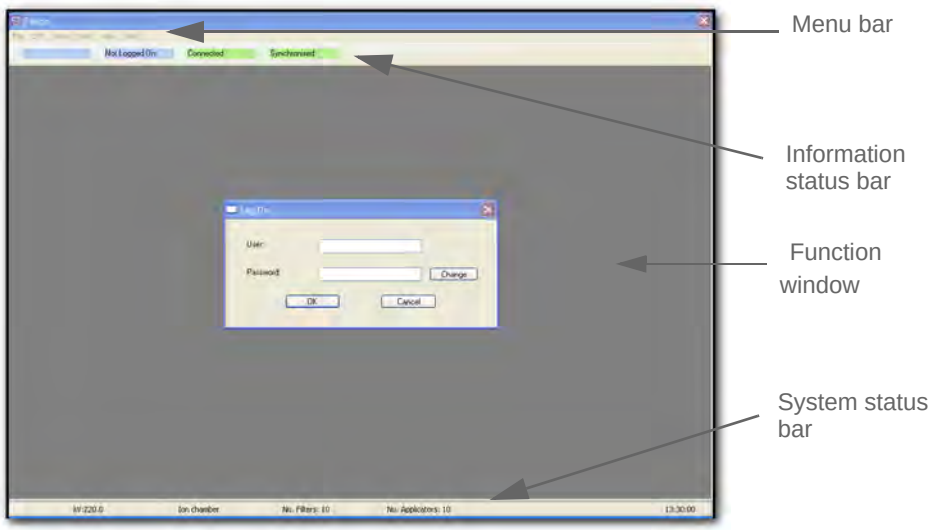
Before attempting to retry communication, check the following:

- Is the mains isolator switched on?
- Is the TP2 powered on inside the treatment room?
- Is the switch on the side of the TP2 CCU unit on?
- Is the operator pod key switch set to standby (position 2)?
- Is the mains light illuminated?
- Are any emergency stop buttons depressed on the operator pod and inside the room?

To re-establish communication, select *Continue* to open physics (housekeeping purposes).

3.2 Home Screen

Figure 3–5: Home



The *Home Screen* includes a *Menu Bar*, *Information Status Bar*, *Function Window* and *System Status Bar*.

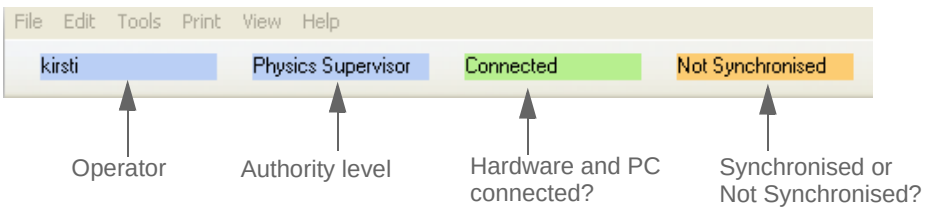
3.2.1 Menu Bar

Figure 3–6: Menu Bar

The *Menu Bar* provides the primary user functions. It consists of *File*, *Edit*, *Tools*, *Print*, *View* and *Help* menus.

3.2.2 Information Status Bar

Figure 3–7: Information Bar (Operator Name/Status)



The coloured Information Status Bar (blue, green and orange) displays the following information:

- Operator name logged onto Fisica (kirsti, blue)
- Operator authority (Physics Supervisor, blue)
- If the hardware and PC are connected (Connected, green) and
- If the databases containing the system configuration data are synchronised (Not Synchronised, orange).

3.2.3 Function Window

The function window or central portion of the *Home Window* displays the dialogue boxes or message windows corresponding to the function selected. When launching Fisica, the function window will display the log on dialogue box (Figure 3–5:). The log on dialogue box is where the operator enters their username and password to launch Fisica. *For more information on usernames and passwords, see Users* See section 3.2.19.

3.2.4 System Status Bar

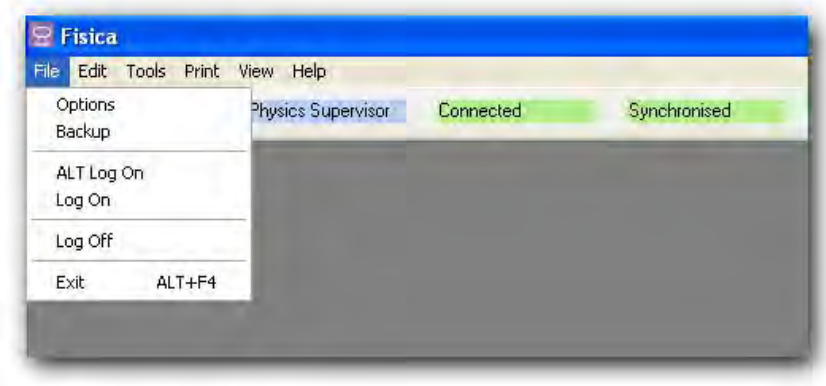
Figure 3–8: System Status Bar

The system status bar displays the following information:

- System kV limit
- If the unit is an ion chamber (dose) or no dosimeter (time)
- Number of filters and
- Number of applicators set up on the system

3.2.5 File Menu

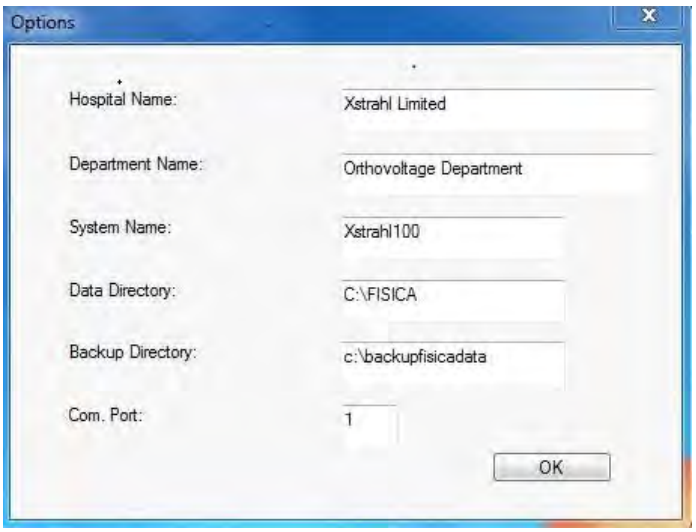
Figure 3–9: File Menu



The *File Menu* consists of *Options*, *Backup*, *Alt+Log On*, *Log On/Off* and *Exit* options.

3.2.6 Options

Figure 3–10: Options Window



The Options window is used to customise the printed reports and define locations of files:

- Hospital name
- Department name
- System name
- Data directory location (C:\Fisica)
- Backup directory location (defined by user)
- Com. Port number can be defined for serial communication between the PC and TP2 hardware

To save changes to the database, *select OK*.

3.2.7 Backup

The backup option allows each of the four databases (settings, filter data, applicator data, and applicator factors) to be backed up to the location specified in the *Options Menu* (Backup Directory).

It is worth creating a backup of the user password information when users make changes (for example, to create or delete users).

To perform a *Backup*, select *File*, then *Backup*. Each database will automatically be backed up. A success message will appear after each successive completion.

Figure 3–11: Backup Success Message

3.2.8 Authority User Access

To gain access to the system setting and higher level functionality, operators must first be defined on the system. Different system user access levels are created through the new user function, see UsersSee section 3.2.19.

The different access levels and associated access rights are as follows:

- *Radiographer*

  Radiographer has view system settings access and can conduct a warm-up and QA exposure.

- *Physicist*

  Physicist has the same level access as *Radiographer*, but with additional authority to conduct filter and filter reference calibrations.

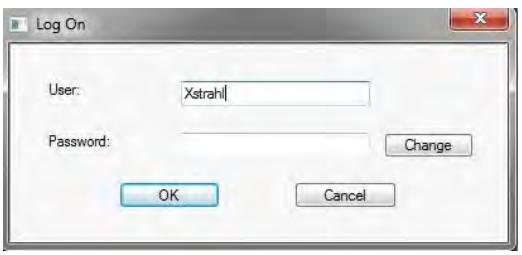
- *Physics Supervisor*

  Physics Supervisor has the same level access as *Physicist*, but with additional authority to change system settings (*for example*, maximum kV limit and maximum dose and time values) and edit filter and applicator data.

Once a user name and password have been created and an access level defined, users can log on to gain access to certain functionality (dependent on the user level).

3.2.9 Log On/Off

Figure 3–12: Log On Window



To log on:

1. Select *File*, then *Log On*
2. Enter *username*[1] (as registered) and *password*

The username and authority level (for example, Physics Supervisor) will be

1. Usernames and passwords are case sensitive

displayed in the information status bar.

If the user is not recognised by the system, a warning message advising the log in failed will appear.

Figure 3–13: Problem Message (Log in Failed)

3.2.10 Log Off

Operators should log off at the end of a session to protect the system security.

To log off, select *File*, then *Log Off*. The system status bar will display no user logged on.

3.2.11 Exit

To exit *Fisica*, select *File*, then *Exit*

3.2.12 System Configuration

Prior to making any changes to the system, including filter and applicator data, select tasks should be completed as part of essential housekeeping.

To configure the system prior to making changes:

1. Enter *hospital* and *department* name by selecting *File*, *Options*
2. Enter *usernames* and *authorities* by selecting *Edit*, *Users*. Enter the following information in the Edit/Add User Detail Window: name, department name, user name (usually with acceptance of the user), users status (edit status not required in Fisica).
3. Select *OK* to save the record
4. Synchronise the system clocks:
    - 4.1 Select *Tools*, then *Clocks*
    - 4.2 Select the *adjust button* (next to the TP2 and generator clock values) to change the time displayed to synchronise with the PC clock.
    - 4.3 Select *Refresh* to update the displayed time values.
    - 4.4 Select *Cancel* to exit
5. Calibrate Gas Law (dose systems only)
    - 5.1 Select *Tools*, then *Calibrate Gas Law*

5.2 Enter the *millibar value* (should be within 700 to 1200 millibars). If the pressure sensed by the TP2 is outside of this range, then a bad pressure error will appear.

5.3 Select *OK*

6. Adjust pod settings:

6.1 Select *Tools*, then *Pod Settings*

6.2 Adjust buzzer volume (1 to 9)

6.3 Select *Set*

6.4 Activate the *X-Ray On* flashing light by selecting the tick box. Disabling the tick box activates the light continuously during an exposure

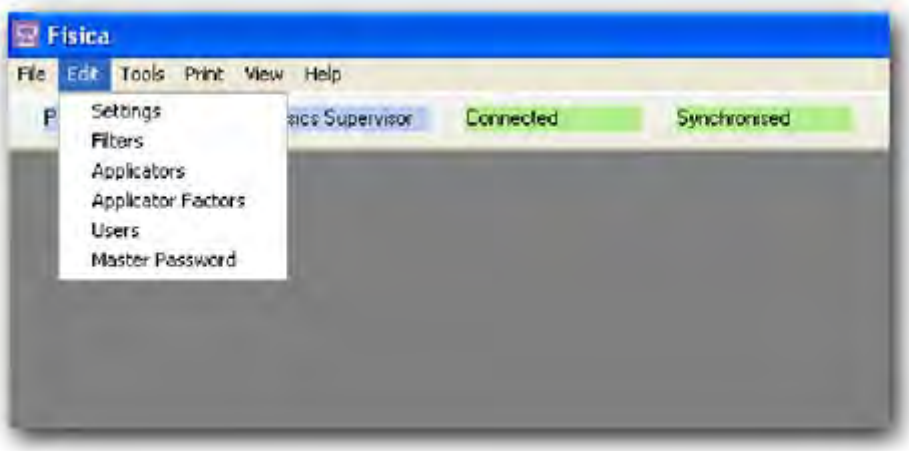
6.5 Select *Set*

7. Backup initial databases:

7.1 Select *File*, then *Backup*

3.2.13 Edit Menu

Figure 3–14: Edit Menu



The *Edit Menu* options are linked to the five main configuration databases, synchronised between Fisica and the TP2 firmware, which ensure full functionality between hardware and software components.

The *Edit Menu* consists of *Settings*, *Filters Applicators*, *Applicator Factors* (dose systems only), *Users* and *Master Password* options.

3.2.14 Settings

Figure 3–15: Settings Window

CAUTION: Always allow the cooler to run after the last exposure to cool down the system. The X-Ray tube anode operates at very high temperatures and shutting down the cooler at the termination of treatment can cause irreparable material damage to the anode surface, which can affect the beam properties and cooling mechanism.

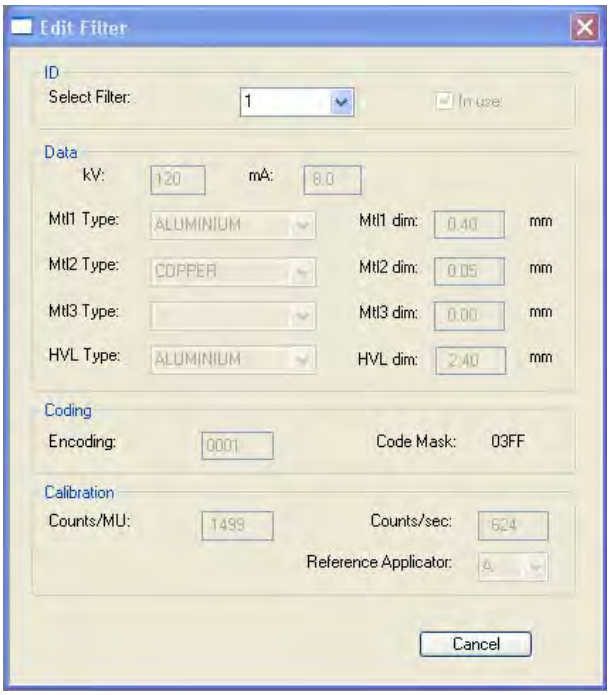
The settings options enables system parameters to be configured. All user levels can view system settings, but only *Physics Supervisors* can edit (certain) settings. The system configuration, as defined during production, will be displayed in the settings window.

Settings Options	
Polarity	Code masks are the hexadecimal switch map for filter and applicators. This is for information purposes only and cannot be changed by the user.
Dosimeter	The dosimeter data identifies the system as a time or dose system. This is for information purposes only and cannot be changed by the user.
Filter configuration	The filter configuration identifies whether the system has a filter ladder identified as a 3150 (150 kV system) or filter recognition within the sub-tube of the system (defined as customer). This is for information purposes only and cannot be changed by the user.

Settings Options	
No. filters/No. applicators	The number of filters and applicators supplied with the system are displayed.
Code masks (filter and applicator)	Code masks are the hexadecimal switch map for filter and applicators. This is for information purposes only and cannot be changed by the user.
kV limit	The kV limit is the top operating limit of the system. This can be adjusted to cap the system at the lower kV value if required.
Millibars and counts	The millibars and counts boxes display the calibration data for the pressure readings on the system; calibrated through the calibrate gas law function. This option is only available for dose systems. The temperature reading is an absolute value that does not require calibration.
Warm-up power	The warm-up power of the system is displayed as a percentage value and is set at the time of production.
Shutdown delay	The shutdown delay value is the cooling system run on time between the last exposure and the time the cooling system shuts down; the minimum time is 10 minutes. Once the X-Ray operator pod is powered off, the cooling system will continue to run for an allotted time before shutting down (the TP2 mains isolator must be left on otherwise all system power, including power to the cooler, will be removed).
Maximum time	Maximum time value is the maximum exposure time that can be set. This is a generic value and is not filter dependent. The absolute time value cannot exceed 40 minutes. A dose system maximum time value is applied to channel 2 (time limit). If the time limit calculated exceeds the maximum time value, the exposure will be prohibited regardless of the MU value entered. A prohibited exposure error will prevent the exposure from being delivered. A time system maximum time limit will be applied to channel 1 (time value). The default setting is 10 minutes.
Maximum dose	Maximum dose value is the maximum MU value that can be set on the system. This is a generic value and is not filter dependent. The absolute value which cannot be exceeded is 9999 MU. The default setting is 1000 MU.
Save	Selecting the *Save* button will write the changes to the database. The *Save* button will then disappear from the window.
Cancel	Selecting *Cancel* will exit the system.
Undo changes	Selecting *Undo Changes* will undo any changes not saved. Any changes will make the system synchronisation status false. Write TP2 is essential after any changes have been made.

3.2.15 Filters

Figure 3–16: Filter Window (Inactive)



The system can have a maximum number of 10 filters; 1[2] warm-up and 9 clinical (if less than 9 HVL's were requested, the remaining filter holders will be supplied empty). The maximum number of filters configured on the system (as defined in the settings menu) is displayed in the bottom status bar.

The *Edit Filter Window* enables the clinical filter parameters to be edited. Any level user can view the filter parameters, but only a physics supervisor can change the filter settings. The system is supplied with filters configured as per the system order.

Note: No edits can be made to the warm-up filter.

3.2.16 Editing Filters

Only users with *Physics Supervisor* access can edit filter data.

To edit a filter:

1. Select the required *filter* from the ID field menu
2. Select the *Edit* button to activate the filter parameters

2. The Xstrahl 100 has 5 clinical filters and 1 warm-up filter

Figure 3–17: Edit Filter (Active)

3. Select (or deselect) the in use box to make a filter available for clinical use. Only the in use filters can be used for clinical exposures.

Edit Filter Values	
Select filter (ID)	The select filter ID section allows the user to select a filter by number and define if that filter is in use. Only in use filters are displayed in the calibrate filter and calibrate applicator fields. Only in use filters are displayed for use in clinical mode.
Data	The data for the filter selected will be displayed in the data section. The data section displays the kV and mA values set for the filter selected, in addition to the filter and HVL materials (mm). The kV and mA values for the filter can be changed if they are within the limits of the system. If they are set outside the system limits, it will not be possible to write the filter database to the TP2; the write process will fail with a Generator kV not set error.
Coding	The coding (encoding) section displays the configuration data (encoding and code mask) for the systems filter recognition. The filter encoding can be altered by a Physics Supervisor, but it is not possible to alter the code mask. It is not advisable to alter the encoding because the system will not be able to recognise the filter ID. The coding data does not need to be altered unless an additional filter is to be added to the system. The encoding identifies the individual filter and the encoding mask defines a digital pattern to differentiate between filters.

Edit Filter Values	
Calibration	The calibration field displays the calibration data for that particular filter. The reference applicator field enables an applicator to be selected as the designated reference applicator for that filter. Once a filter has been calibrated, the counts/sec and the counts/MU calibration values are displayed. Calibration data is entered automatically once a filter calibration is conducted on the system. Deleting these values will assign a filter that is not calibrated and therefore it will not be possible to use this filter until it is recalibrated. The calibration field is not required on a time-based system and is inactive (grey).
Filter thickness/ material	The filter materials and thickness can be adjusted by selecting the required materials form the drop-down menus. The thickness of each material can also be changed (thickness displayed is in mm). The HVL material and thickness can be altered in the same way.

To write changes to the filter database:

1. Select *Save* to write the changes to the database. An *OK* screen will appear.
2. Select *OK*. To exit without saving changes, select *Cancel*.

To make further changes, select *Edit* (again). Once *Save* has been selected, the synchronisation status will display *not synchronised*.

Figure 3–18: Not Synchronised Message

Note: Once changes have been made to the filter data, the user must synchronise the databases between Fisica and the TP2 by selecting Write TP2.

If the filter database is not synchronised, the user will not be able to calibrate the filter or select the filter for QA or treatment exposure in clinical mode.

3.2.17 Applicators

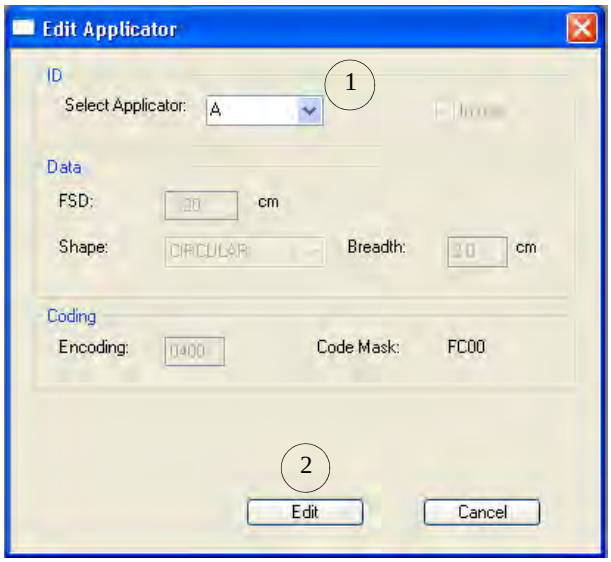
Xstrahl systems are supplied with a standard number of configured applicators:

- Xstrahl 100 (6)
- Xstrahl 150 (8)
- Xstrahl 200 (10)
- Xstrahl 300 (10)

The number of applicators set on the system is displayed in the *System Status Bar*. The maximum number of applicators configurable on any system is 26.

The *Edit Applicator Window* enables the applicator parameters to be edited if necessary. All users can view the applicator parameters (Edit button is inactive), but only users with *Physics Supervisor Authority* can edit applicator parameters.

Figure 3–19: Edit Applicator (Inactive)



To edit an applicator:

1. Select an applicator (letter A to Z) from the ID field menu.
2. Select *Edit* to activate the applicator parameters

Figure 3–20: Edit Applicator (Active)

3. Select (or deselect) the in use box to enable applicators for clinical use. Only the in use applicators will be available for QA exposures and patient treatment.

The data section displays the shape (circle, square rectangle), size (cm) and FSD (cm) of the selected applicator. The encoding value is used to identify the individual applicator and the code mask is a set value which cannot be altered because it defines a digital pattern to differentiate between different applicators. The applicator encoding can be altered by a *Physics Supervisor*.

It is not advisable to alter the encoding because the system will not be able to recognise the applicator ID. This function should only be used in situations where additional applicators are purchased and added to the system post production.

To write changes to the database:

- Select *Save* or *Undo Changes* to undo edits prior to saving

To *Exit*, select *OK*.

To make further changes:

- Select *Edit* (again)

To Cancel without saving, select *Cancel*.

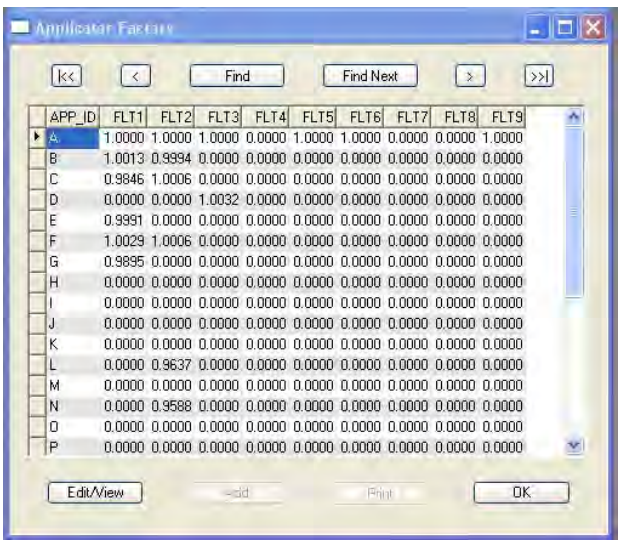
Note: Once changes have been made to the applicator data, the operator must select Write TP2 to synchronise the databases between Fisica and the TP2.

Once edits have been saved, the synchronisation status will display not synchronised (Figure 3–18:).

If the applicator database is not synchronised, the user will be unable to run an exposure (either Calibration, QA or Clinical).

3.2.18 Applicator Factors (Dose Systems)

Figure 3–21: Applicator Factors Window



The *Applicator Factors Window* displays the calibration factors for each applicator and filter combination. This data is used to generate the applicator factors printout.

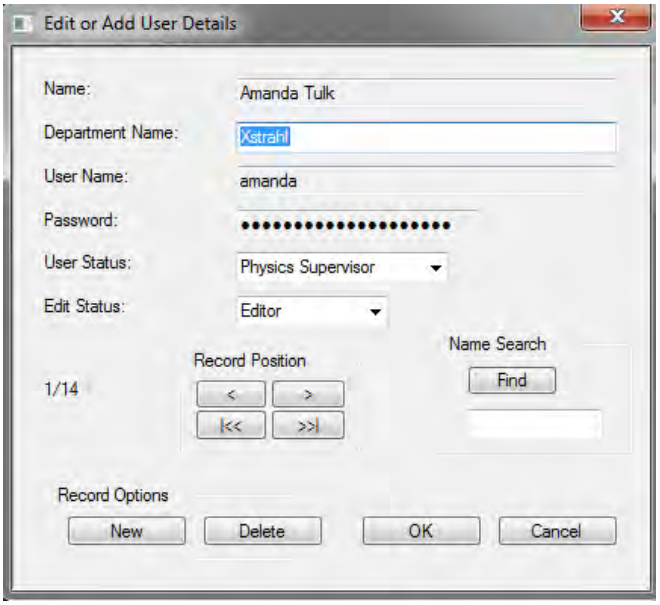
Some calibration factors:

- A factor of 1.0000 indicates a reference filter/applicator combination
- Factors other than 1.0000 indicates an additional applicator is calibrated to that filter
- Factors of 0.000 indicate the filter/applicator combination has not been calibrated will not be available for clinical exposures.

The *Applicator Factors Table Data* can be edited by a Physics Supervisor only. Any changes made to this data is recorded in the changes database.

3.2.19 Users

Figure 3–22: Edit or Add User Details Window



The *Edit* or *Add User Details* Window enables new users to be created (in addition to general housekeeping of other registered system users). Access to this window will depend on the knowledge of the master password. All sites should have at least one appointed password administrator.

To create a new user:

1. Select *Edit*, then *Users*
2. Select *New* and enter the following information in the *Edit* or *Add User Detail* window: name, department name, username[3], user status[4]
3. Select OK to save the record

Figure 3–23: Log On (Password Window)

Passwords are entered/changed by the user at log in.

4. Enter a username
5. Select *Change*
6. Enter the *password*, or if a new user enter the current password, then new password (twice) if changing a password.

3. With acceptance of the user
4. Edit status is not required in Fisica

7. Select *OK* to save changes made and exit the window

Once the password has been saved, users can proceed to *log in*. If a password is misplaced or forgotten, the administrator can use the *Delete* button to either delete the user or delete the currently stored password.

Other housekeeping activities can be performed in the user window, such as deleting obsolete or incorrect entries by finding the relevant entry and selecting delete. Cursor tabs can be used to scroll through the records, whilst the search facility allows users to be located by name.

3.2.20 Master Password

The *Master Password* is required to access certain administrative functions. The password is set to default in the factory.

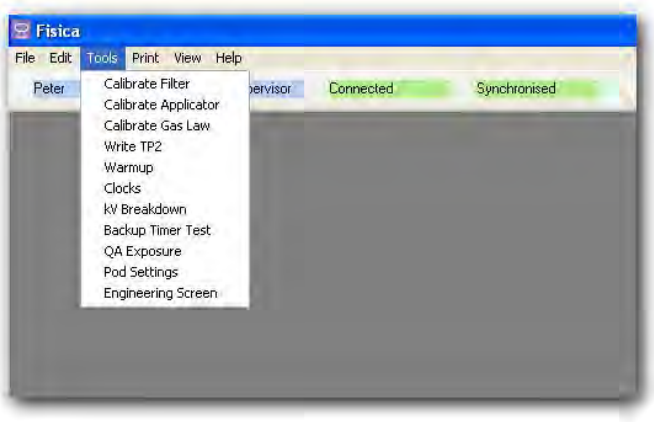
To change a master password:

1. Select *Edit*, then *Master Password*
2. Enter the current password and new password

Note: If a password is changed and has been forgotten, then the administrator must contact Xstrahl Limited to request a new password.

3.2.21 Tools Menu

Figure 3–24: Tools Menu



The *Tools Menu*[5] consists of *Calibrate Filter*, *Calibrate Applicator*, *Calibrate Gas Law*, *Write TP2*, *Warm-Up*, *Clocks*, *kV Breakdown*, *Backup Timer Test*, *QA Exposure*, *Pod Settings* and *Engineering Screen* options.

3.2.22 Dose Systems

The pressure transducer in the TP2 must be calibrated before attempting to calibrate any filters, see Calibrate Gas LawSee section 3.2.24.

The *Calibrate Filter Function* is used to calibrate the selected filter with a reference applicator and can only be conducted by a *Physicist* and *Physics Supervisor* level user. The purpose of calibrating filters is to establish the nominal dose rate for that

5. Several Tools Menu options are only available with dose systems and will be inactive (grey) on a time system.

filter with a specified reference applicator. The calibrate applicator function enables other applicators to be calibrated to that filter.

Note: The reference applicator must be defined for each filter in the Edit window (edit; filter and select the required filter, see Editing Filters See section 3.2.16.

The calibration process measures the electrometer pulses from the ion chamber over a 1 minute exposure. This exposure period is the default setting in Fisica. During the exposure an independent chamber should be positioned at the end of the reference applicator. The position of the chamber should correspond with the local commissioning protocol used (such as the IAEA or IPEM code of practice).

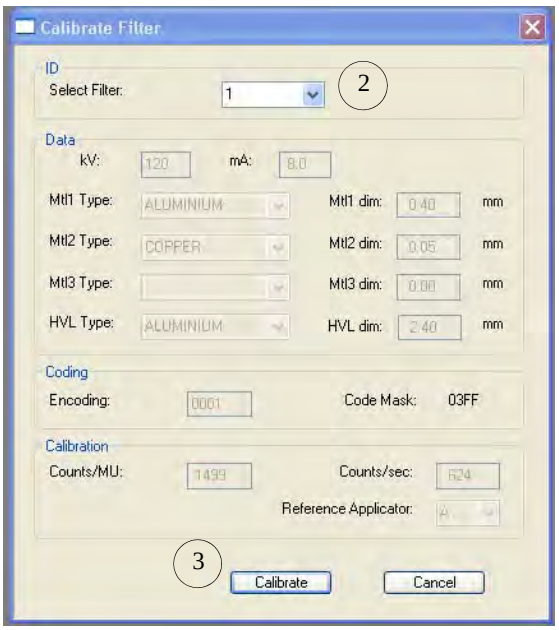
At the end of the calibration exposure, the operator will be prompted to enter the value (MU) recorded from the independent ion chamber; 1 MU should equal 1 cGy. If the measured value from the calibration exposure is 300 cGy/min, then this equals 300 MU/min. Thus, 300 MU/min will be the nominal dose rate for that particular filter and applicator combination.

To calibrate a filter:

1. Select *Tools*, then *Calibrate Filter*

Ensure the reference applicator is first defined in the *Edit Filter Window*.

Figure 3–25: Calibrate Filter (Select Filter)

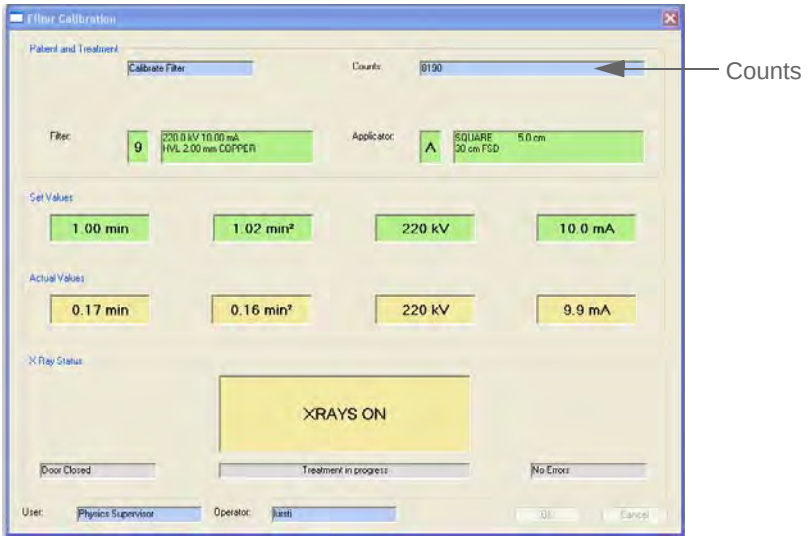


2. Select the required filter to be calibrated from the *Select Filter Menu*. The data section will display the information for the filter selected. The reference applicator is displayed at the bottom of this window.

Once the required filter and applicator are fitted to the machine and the independent ion chamber is correctly positioned, the calibration can proceed.

3. Select *Calibrate*

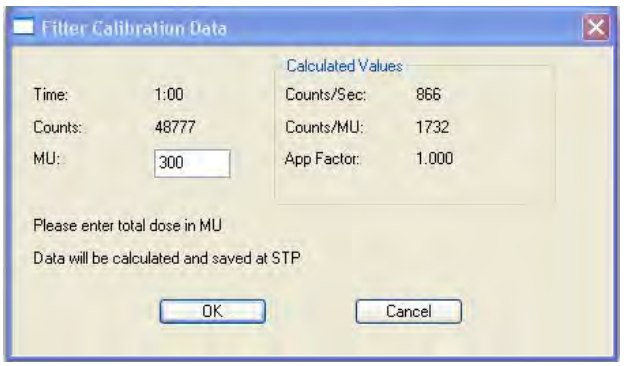
Figure 3–26: Filter Calibration Parameters Window



The selected filter and applicator information will be displayed with the exposure time set to 1 minute. Once all the interlocks have been satisfied the exposure can begin.

4. Turn the operator pod key switch to *HT* (position 2)
5. Press *X-Rays On* (illuminated). The accumulated electrometer counts will be displayed in the *Counts* field.
6. When the exposure is complete, return the key switch to *Standby* (position 2) and select *OK*.

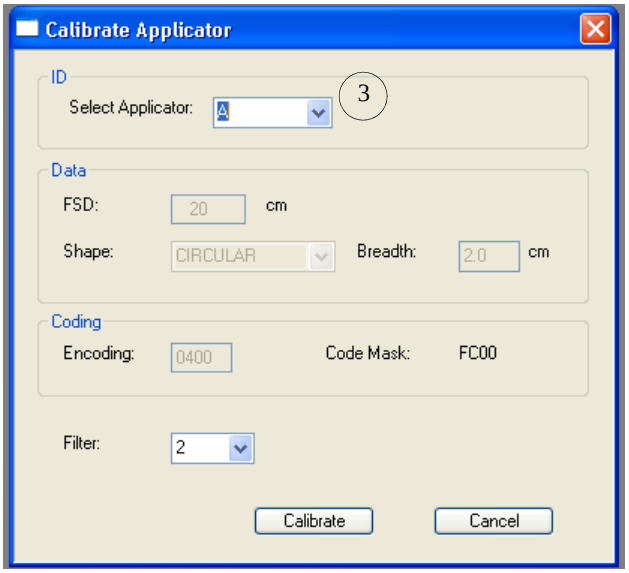
Figure 3–27: Filter Calibration Data



7. Enter an MU value (1 cGy = 1 MU) as recorded on the independent ion chamber
8. Select *Write* to write the information to the TP2. Once *Write* is selected the button will change to *OK* and the calculated values for counts/sec, counts/MU and App Factor will be displayed. The calculated values are stored at standard temperature and pressure. The applicator factor for reference calibration is always 1.000.
9. Select *OK* to close the window

3.2.23 Calibrate Applicator

Figure 3–28: Calibrate Applicator



The *Calibrate Applicator* function is used to calculate the applicator coefficient factor. The coefficient is the ratio between the electrometer pulses from the reference calibration and an exposure with a non-reference applicator. The ratio is due to scatter[6] from the top collimator of the applicator onto the ion chamber (they sit next to each other in the sub-tube assembly). Each applicator must be calibrated with the filter it is used with.

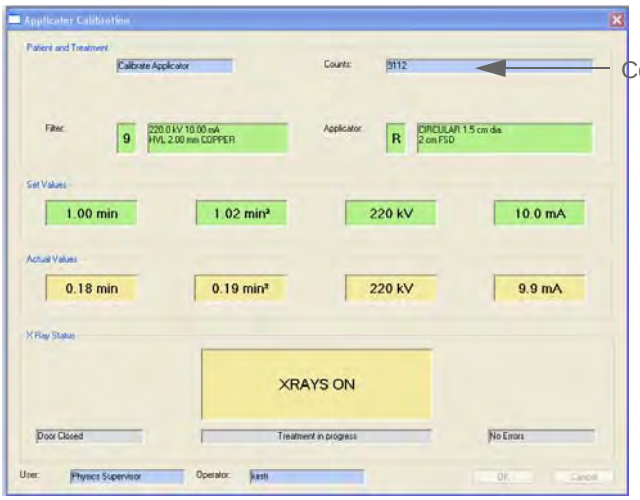
To calibrate an applicator:

1. Fit the filter and non-reference applicator to be calibrated into the machine
2. Select *Tools*, then *Calibrate Applicator*
3. Select the *applicator* to calibrate from the *Select Applicator Menu* and select *Calibrate*

All filters available for calibration with the selected applicator will be displayed in the *Filter Menu*. Only filters assigned *in use* and not assigned with the selected applicator for reference calibration will be available.

6. This is not Back Scatter Factor (BSF), where the reflection of waves or particles are reflected back to the direction they had come, but merely a measurement of mechanical scatter.

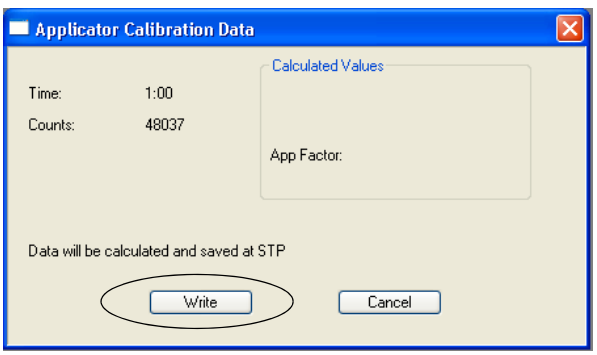
Figure 3–29: Applicator Calibration



The selected filter and applicator information will be displayed and the exposure time set to 1 minute. Once all of the interlocks have been satisfied, the exposure can begin.

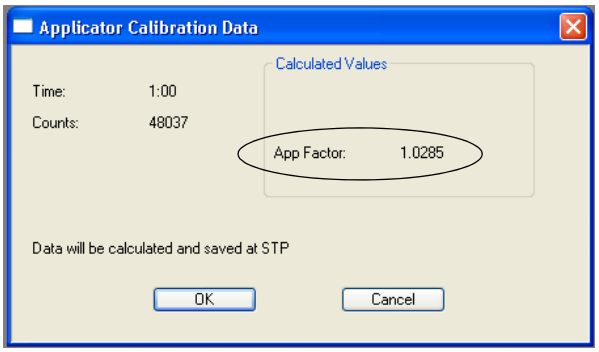
4. Select *OK*
5. Turn the key switch to *HT* (position 3)
6. Press *X-Rays On*. The accumulated electrometer counts will be displayed in the Counts field.
7. After exposures have run, return the key to *Standby* (position 2) and select *OK*

Figure 3–30: Applicator Calibration Data (Write)



The exposure time and electrometer counts will now be displayed. Once the data is written, the system will automatically calculate the applicator factor value.

Figure 3–31: Applicator Calibration Data (Applicator Factor Value)



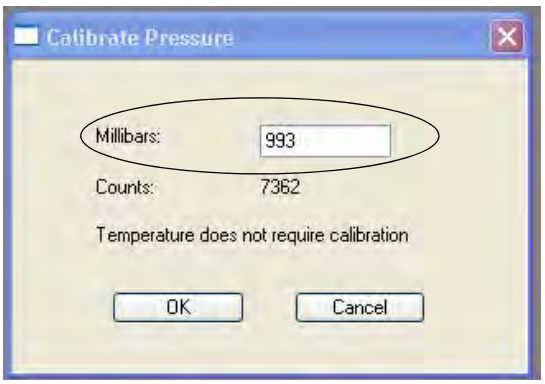
The applicator factor value will be +/- 1.000; 1.000 is the reference factor. Data is calculated at standard temperature and pressure.

There is no sequence to the factors; they will not start at 0.9800 and increase to 1.100 with increasing applicator field size. The applicator factors are dependent on the shape and size of the top collimator of the applicator, and will present as a varying set of values.

8. Select *Write* to write the factors to the database, or select *Cancel* to exit without saving the calibration data.
9. Select *OK* to close the window

3.2.24 Calibrate Gas Law

Figure 3–32: Calibrate Pressure



The pressure sensor counts should be calibrated against the actual pressure reading in millibars.

To calibrate pressure:

1. Select *Tools*, then *Calibrate Gas Law*
2. Enter the millibar value (should be within 700 to 1200 millibars). If the pressure sensed by the TP2 is outside of this range, then a bad pressure error will appear.
3. Select *OK*

The temperature value is an absolute value and does not require calibration. For temperature readings, see *Settings*.

The temperature range is *10 to 35 degrees*; if there is no signal or the temperature is outside of the defined range, then a bad temperature error will appear.

3.2.25 Time Systems

The available filter and applicator choices in a time-based system will depend entirely on the in use parameters.

3.2.26 Generic System Tools

Generic system tools available for both time and dose systems:

- Write TP2
- Warm-Up
- Clocks
- kV Breakdown
- Backup Timer Test
- QA Exposure
- Pod Settings
- Engineering Screen

3.2.27 Write TP2

Write TP2 writes the contents of the Fisica databases to the TP2 firmware. These databases should be synchronised after any changes have been made to the system, otherwise the system will not allow clinical exposures to be conducted.

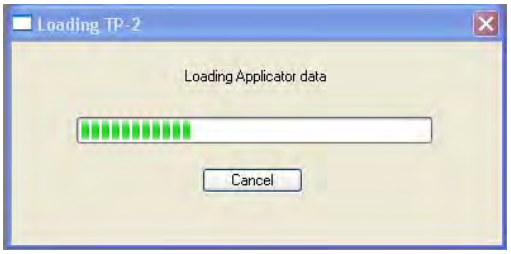
Only users with *Physics Supervisor* level access can write settings to the TP2, and only then can they write settings which they have permission to edit. During Write TP2, the filter database, applicator, applicator factor database and the settings database values are written to the TP2.

To write to the TP2:

1. Select *Tools*, then *Write TP2*
2. Select *Start* to write data

A Loading TP-2 progress message will appear advising the databases are copying to the TP2 hardware.

Figure 3–33: Loading TP2 Applicator Data Message



If the Write TP2 operation results in synchronisation of both systems, a success message will appear. The information status bar at the top of the screen will indicate

once the databases are synchronised.

Figure 3–34: Information Status: Synchronisation

3.2.28 Warm-Up

Figure 3–35: Select Warm-Up Window

Warm-up[7] enables the user to conduct a warm-up from within Fisica and is available to all user levels.

To conduct a warm-up:

1. Select *Tools*, then *Warm-Up*

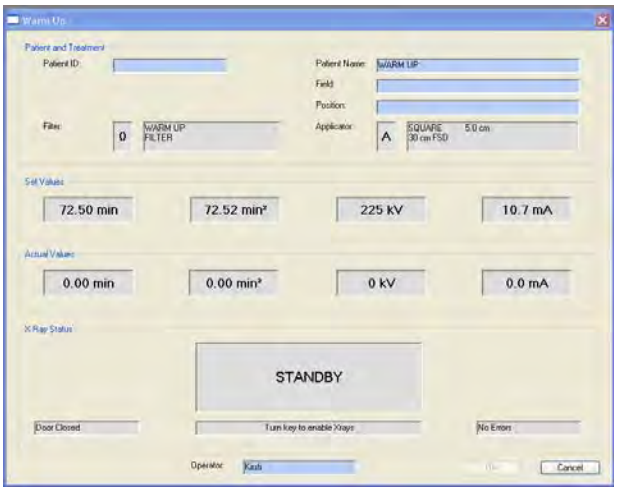
The system will automatically highlight the warm-up required depending on the date of last use, however the user can conduct either a short or long warm-up as required.

The warm-up can be conducted with any applicator, but there must be an applicator fitted because it is not possible to conduct an exposure if the applicator interlock is not satisfied.

2. After ensuring the warm-up filter is in the head of the machine, enter a *username*[8] into the operator field.
3. Select *Apply*

7. Warm-up lengths displayed are for the Xstrahl 200. These values are system dependent.
8. At least 3 characters

Figure 3–36: Warm-Up Values Window



The warm-up program uses a model which applies a constant mA with an exponential kV. This has the added advantage of not running the X-Ray tube at such high initial filament temperatures and spending more time conditioning at the higher voltages, thus preventing thermal shock and prolonging the life of the tube.

The warm-up will initially calculate the final mA value at the system kV limit and the warm-up power percentage. The warm-up begins at half the kV limit and half the final mA. At constant mA, the kV increases exponentially over several minutes until it reaches the kV limit. At this point the system is at half warm-up power. The mA is then doubled over 5 seconds and the system will hold at full warm-up power for 5 minutes.

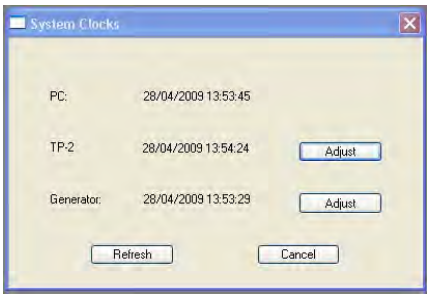
If the daily warm-up has already been conducted, the system will display a *Warm-up Not Required Message*.

Figure 3–37: Warning: A Warm-Up is Not Required Message

4. Select *Continue* to conduct an additional warm-up or *Abort* if not performing an additional warm-up.

3.2.29 Clocks

Figure 3–38: System Clocks



The system contains three independent clocks: one on the PC, TP2 firmware and in the generator.

The synchronise clock function sets all system clocks to correspond with the PC clock. It is important to ensure accuracy of the PC date and time before synchronising system clocks. Once synchronised, all functionality completed on the system is written into the relevant databases under the same time record (can assist with fault finding).

To synchronise system clocks:

1. Select *Tools*, then *Clocks*
2. Select the *adjust button* (next to the TP2 and generator clock values) to change the time displayed to synchronise with the PC's clock.
3. Select *Refresh* to update the displayed time values
4. Select *Cancel* to exit

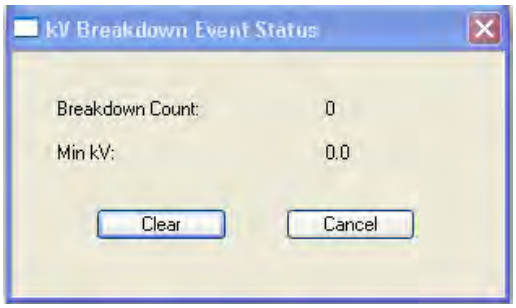
3.2.30 kV Breakdown

The *kV Breakdown* records any HT cable failure by monitoring and recording the kV values at which the system fails.

For example, If a cable fails at 180 kV, the system will record 180 kV. If the user tries to use the system again and the cable then fails at 160 kV, the second record will be 160 kV. If on a third attempt the system failed at 140 kV, the third record will be 140 kV.

The system will lock out on the third record and the last value will be displayed in the dialogue box and the number of attempts recorded. This functionality is unique to HT cable failures or solid dielectric failures in the generator or tube. If a system fails at 180 kV, 160 kV and then 180 kV, the kV breakdown will be reset to zero. This is representative of breakdown in a vacuum rather than a solid dielectric.

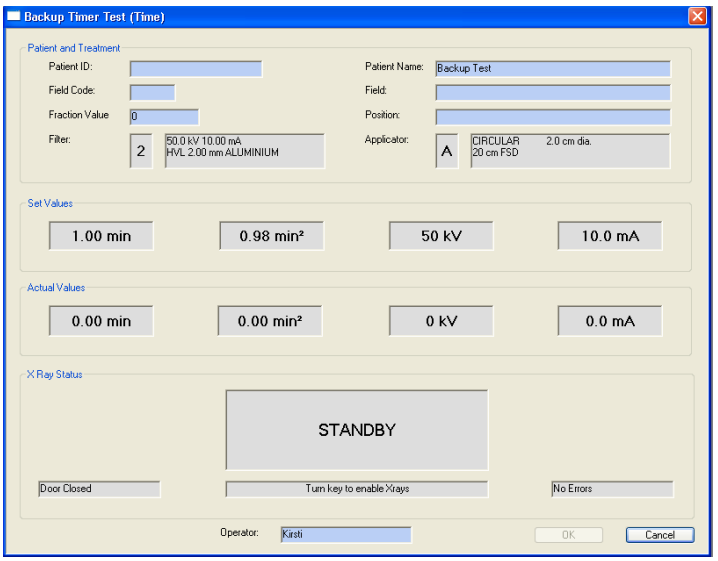
Figure 3–39: kV Breakdown Event Status



3.2.31 Backup Timer Test

The *Backup Timer Test* is available on both time and dose-based systems. In time mode, the backup timer sets the channel 2 value at 0.05 min. less than the primary timer value. *For example*, In dose mode, test sets the time limit value to 5% less than the calculated exposure time. In clinical mode, the time limit value is set to calculate exposure time plus 5% or 0.05 min., whichever value is greater.

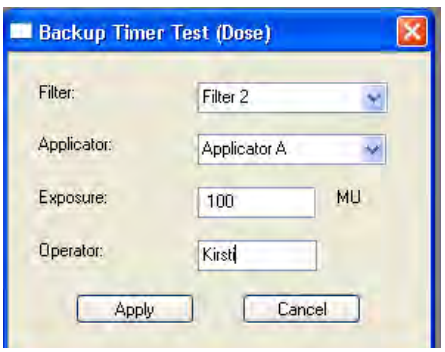
Figure 3–40: Backup Timer Test (Time)



To run a backup timer test:

1. Select *Tools*, then *Backup Timer Test*[9]

Figure 3–41: Backup Timer Test (Dose)

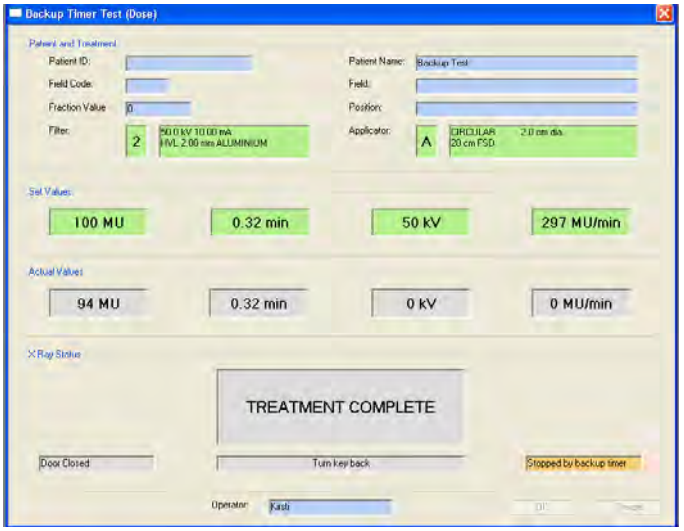


9. Backup timer test (dose) or dialogue window (time) are displayed dependent on system.

2. Select a *filter* and *applicator*
3. Enter an exposure time in MU's (dose) or decimal minutes (time).
4. Enter an operator name[10]
5. Select *Apply*
6. Turn the operator pod key switch to *HT* (position 3)
7. Press *X-Ray On*

The *Backup Timer Test* treatment window will display the filter, applicator and set exposure value. The patient name field will display *Backup Test*. The channel 2 value will be set as described above (this value will terminate the exposure).

Figure 3–42: Backup Timer Test (Dose)



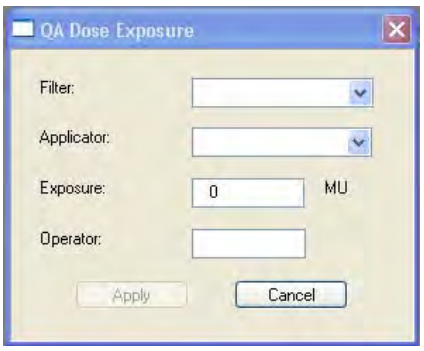
The exposure will stop and the error message, stopped by backup timer will be displayed.

8. To cancel out of the exposure screen, turn the operator pod key switch to *Standby* (position 2). This will illuminate the cancel button.
9. Press the illuminated *Cancel* button

10. At least 3 alphanumeric characters

3.2.32 QA Exposure

Figure 3–43: QA Dose Exposure



The *QA Exposure* function enables operators to perform exposures from within Fisica for quality assurance or system calibration/commissioning purposes.

To perform a QA exposure:

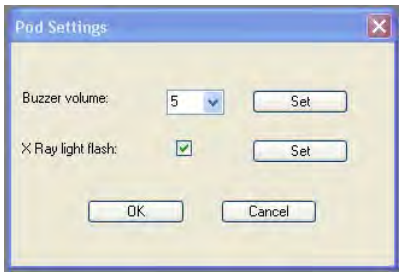
1. Select *Tools*, then *QA Exposure*
2. Select the required *filter* and *applicator*
3. Enter the exposure dose or time (system dependent)
4. Enter the operator name[11]
5. Select *Apply* to deliver the exposure
6. Turn the operator pod key switch to *HT* (position 3)
7. Press *X-Ray On*

Figure 3–44: QA Dose Exposure (Values)

11. At least 3 characters

3.2.33 Pod Settings

Figure 3–45: Pod Settings



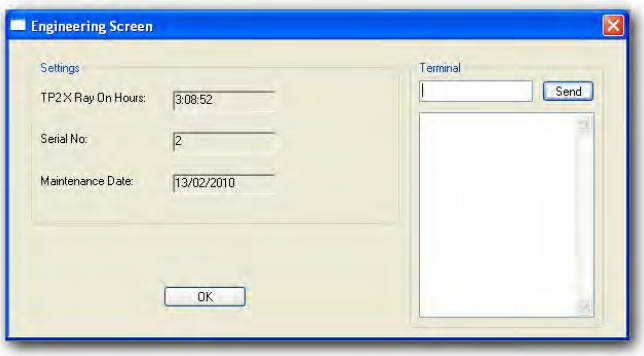
The *Pod Settings* function customises the *X-Ray On* warnings volume and lights.

To customise pod settings:

1. Select *Tools*, then *Pod Settings*
2. Adjust buzzer volume[12] (1 to 9)
3. Select *Set*
4. Activate the *X-Ray On* flashing light by selecting the tick box. Disabling the tick box activates the light continuously during an exposure.
5. Select *Set*

3.2.34 Engineering Screen

Figure 3–46: Engineering Screen

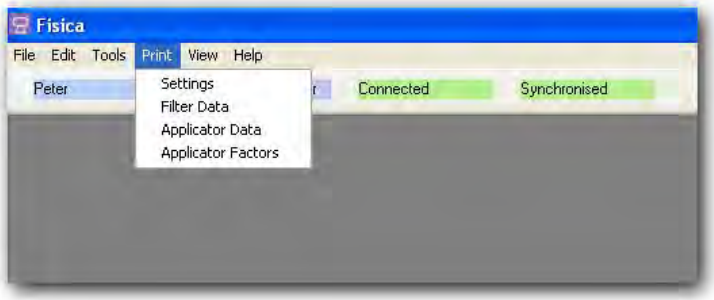


The *Engineering Screen* is available to *Physics Supervisor* level operators and is used to support *Help Desk* diagnostics

12. No 0 option

3.3 Print Menu

Figure 3–47: Print Menu



The *Print Menu* consists of *Settings*, *Filter Data*, *Applicator Data* and *Applicator Factors* menu options.

To print a report:

- Select *Print*, then the *required report* from the print menu

3.3.1 Settings

Settings prints off the following System Settings report:

Figure 3–48: System Settings Report

27/05/2011 **System Settings** 1

Xstrahl Limited

Orthovoltage Department C:\FISICA

D3000 c:\backupfisicadata

	DataBase Values	TP2 Values
System kV Limit:	100	100
Filter Configuation Code:	0	0
Qty OF Filters:	6	6
Qty OF Applicators:	20	20
Filter Code Mask:	63	63
Applicator Code Mask:	64512	64512
Dosimetry Type:	1	1
Pressure Counts:	6664	6664
Pressure mB:	1001	1001
Warmup Power %:	80	80
Generator:	23	23
Xray Tube:	30	30
Protocol:	1	1
Polarity:	0	0
Maximum Dose (MU):	1000	1000
Maximum Time (mins):	10.00	10.00
Cooler Run On Time (mins):	10.00	10.00
TP2 XRay On Hours:	N/A	0:25:07
Date Last Used:	N/A	01/01/2000
Time Last Used:	N/A	00:00:00
Dual Door Enable:	0	0
Serial No:	N/A	2
Maintenance Date:	N/A	01/04/2011

3.3.2 Filter Data

Filter Data prints off the following Report:

Figure 3–49: Filter Data Report

Filter Data

27/05/2011 1

Xstrahl Limited

Orthovoltage Department C:\FISICA

D3000 c:\backupfisicadata

Filter ID: 1

		Reference Applicator:	A	Mtl 1 Type:	1
In use:	True	HVL dim:	0.40	Mtl 1 Dim:	0.25
kV:	30	HVL Type:	1	Mtl 2 Type:	0
mA:	16.0	Counts/MU:	9081	Mtl 2 Dim:	0.00
Encoding:	1	Counts/Sec:	1816	Mtl 3 Type:	0
				Mtl 3 Dim:	0.00

Filter ID: 2

		Reference Applicator:	A	Mtl 1 Type:	1
In use:	True	HVL dim:	1.00	Mtl 1 Dim:	0.80
kV:	50	HVL Type:	1	Mtl 2 Type:	0
mA:	16.0	Counts/MU:	0	Mtl 2 Dim:	0.00
Encoding:	2	Counts/Sec:	0	Mtl 3 Type:	0
				Mtl 3 Dim:	0.00

Filter ID: 3

		Reference Applicator:	A	Mtl 1 Type:	1
In use:	False	HVL dim:	2.00	Mtl 1 Dim:	1.70
kV:	80	HVL Type:	1	Mtl 2 Type:	0
mA:	12.0	Counts/MU:	0	Mtl 2 Dim:	0.00
Encoding:	3	Counts/Sec:	0	Mtl 3 Type:	0
				Mtl 3 Dim:	0.00

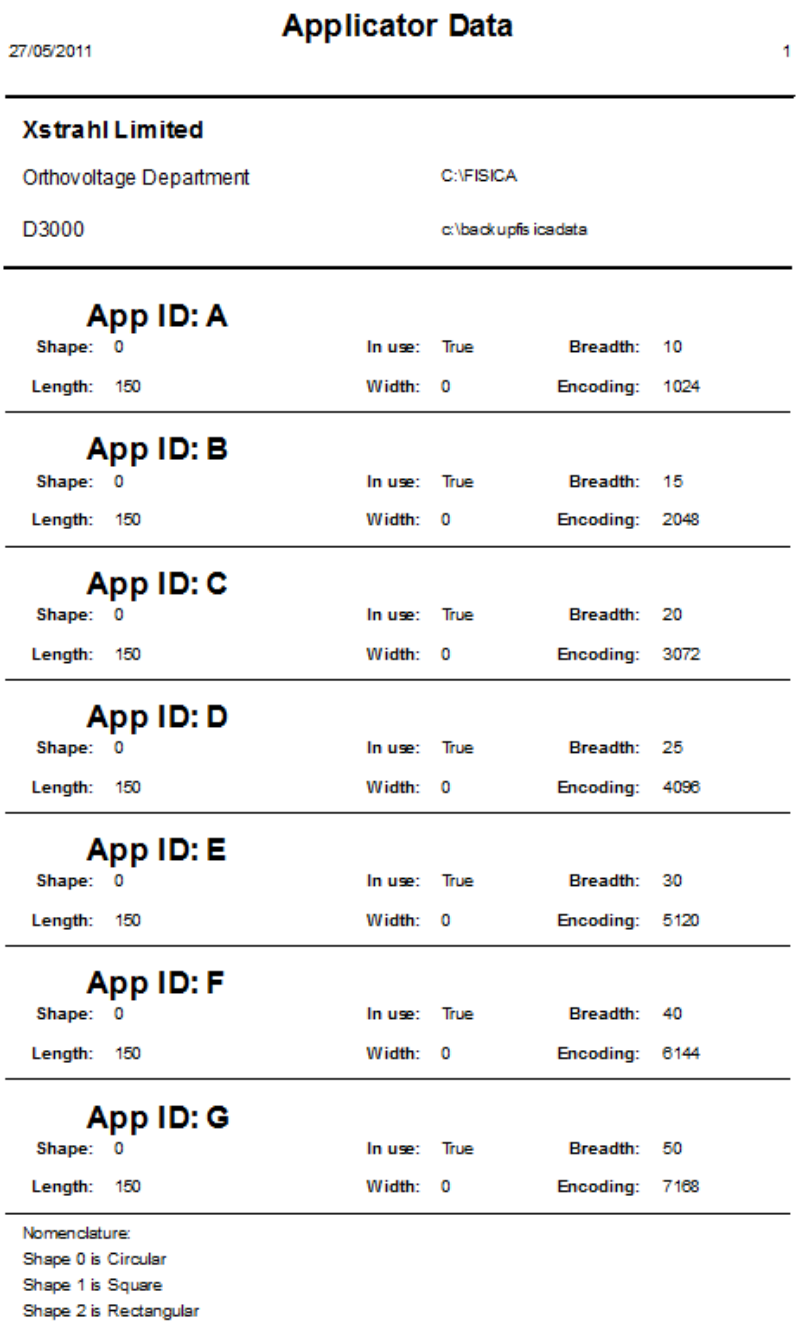
Nomenclature:

Material 0 IS None/Air	Material 2 is Copper	Material 4 is Lead
Material 1 is Aluminium	Material 3 is Tin	Material 5 is Water

3.3.3 Applicator Data

Applicator Data prints off the Applicator Data Report:

Figure 3–50: Applicator Data Report



Applicator Data

27/05/2011 1

Xstrahl Limited

Orthovoltage Department C:\FISICA

D3000 c:\backupfisicadata

App ID: A

Shape:	0	**In use:**	True	**Breadth:**	10
Length:	150	**Width:**	0	**Encoding:**	1024

App ID: B

Shape:	0	**In use:**	True	**Breadth:**	15
Length:	150	**Width:**	0	**Encoding:**	2048

App ID: C

Shape:	0	**In use:**	True	**Breadth:**	20
Length:	150	**Width:**	0	**Encoding:**	3072

App ID: D

Shape:	0	**In use:**	True	**Breadth:**	25
Length:	150	**Width:**	0	**Encoding:**	4096

App ID: E

Shape:	0	**In use:**	True	**Breadth:**	30
Length:	150	**Width:**	0	**Encoding:**	5120

App ID: F

Shape:	0	**In use:**	True	**Breadth:**	40
Length:	150	**Width:**	0	**Encoding:**	6144

App ID: G

Shape:	0	**In use:**	True	**Breadth:**	50
Length:	150	**Width:**	0	**Encoding:**	7168

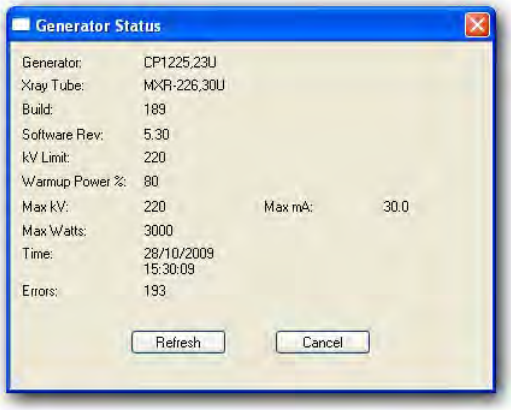
Nomenclature:
Shape 0 is Circular
Shape 1 is Square
Shape 2 is Rectangular

3.4 View Menu

The *View Menu* consists of *Generator Status*, *TP2 Status*, *Changes*, *Generator Log* and *TP2 Log* menu options.

3.4.1 Generator Status

Figure 3–51: Generator Status

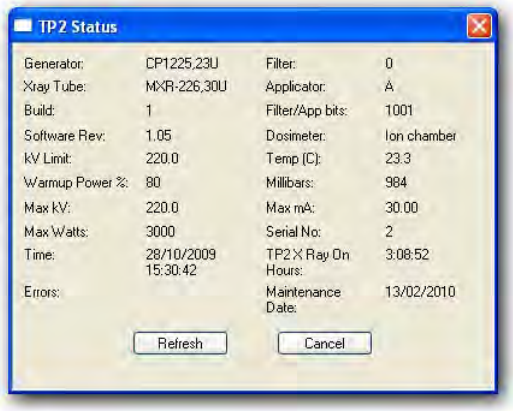


View the generator settings:

- Select *View*, then *Generator Status*

3.4.2 TP2 Status

Figure 3–52: TP2 Status



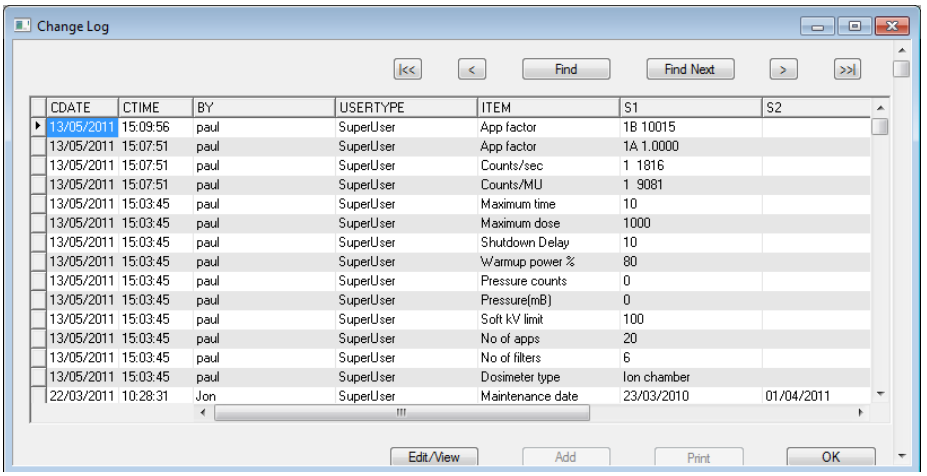
View the TP2's Status:

- Select *View*, then *TP2 Status*

Note: The measured temperature value is displayed in the TP2 Status Window.

3.4.3 Changes (Log)

Figure 3–53: Change Log



The *Changes Database* is a log of all edits made to Fisica. It records which parameters have been changed, the date the changes made and who the operator (including user level) was that made them.

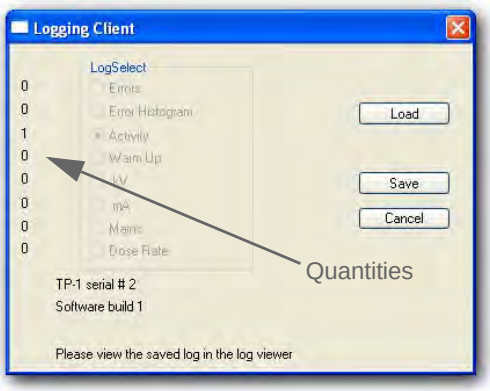
3.4.4 TP2 Log

The *TP2 Log* loads the Logging Client (see below) screen.

To create a TP2 log:

1. Select *Save* to save a log
2. Open a separate log viewer application

Figure 3–54: Logging Client (TP2 Log)



The (system) *Logging Client* views the TP2 system logs. The quantities accumulate whilst the data is read from the TP2.

Logging Client Data (8 Categories)	
Errors	Individual error events (2000 maximum)
Error histogram	Quantities of each individual error
Activity	Activities (*for example*, setting new system kV limit)

Logging Client Data (8 Categories)	
Warm-up	Warm-up (data on each warm-up initiated and each one completed)
kV	Trace of kV at the last error
mA	Trace of mA at the last error
Mains	Trace of the mains supply at the last error
Dose rate	Dose data

To analyse further data:

- Select *Save*

The file name, ending in a.log extension, can either be emailed to the support desk or viewed with the *Xstrahl Logging Client*. This is a separate standalone application.

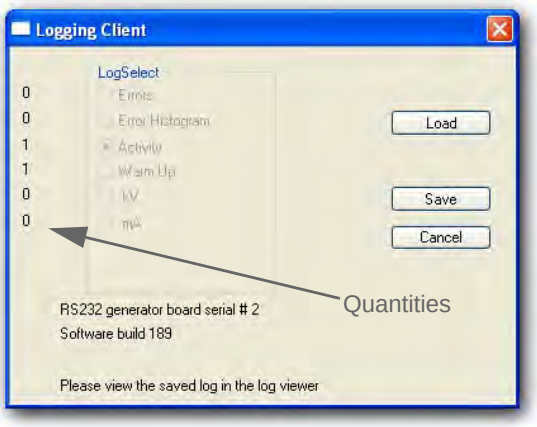
3.4.5 Generator Log

The *Generator Log* loads the *Logging Client* (see below) screen.

To create a generator log:

- Select *Save* to save a log. Open a separate log viewer application.

Figure 3–55: Logging Client (Generator Log)



The (system) *Logging Client* views the generator logs. The quantities accumulate whilst the data is being read from the generator.

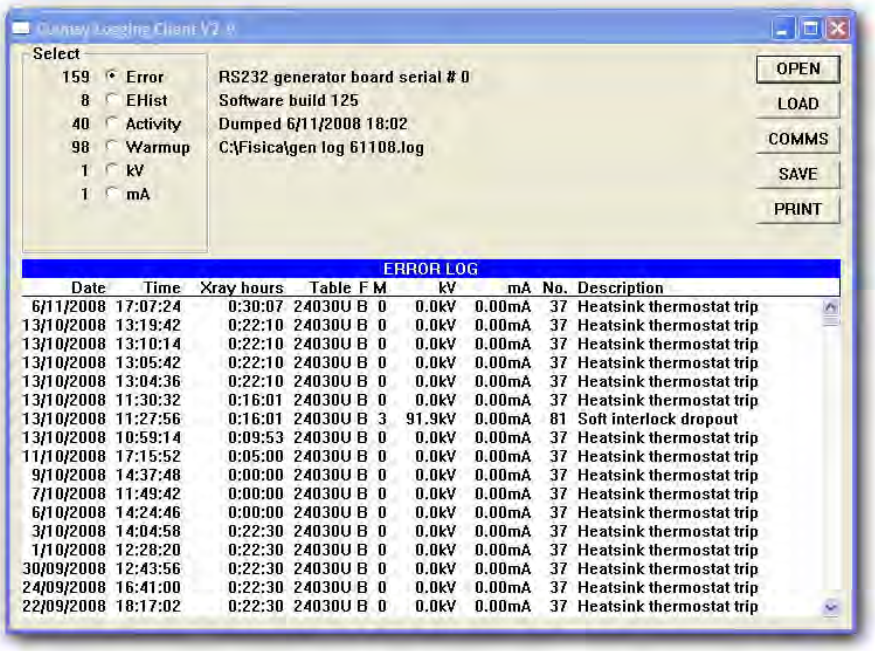
Generator Log Data (6 Categories)	
Errors	Individual error events (200 maximum)
Error histogram	Quantities of each individual error
Activity	Activities (setting maintenance date)
Warm-up	Warm-up (data on each warm-up initiated and each one completed)
kV	Trace of kV at the last error
mA	Trace of mA at the last error

To view details within the log file:

➢ Select *Save*

The file name, ending in a.log extension, can be either emailed to your support desk or viewed with the *Gulmay Logging Client.* This is a separate standalone application.

Figure 3–56: Gulmay Logging Client



The following date is recorded for each error (Figure 3–56:).

- Date and time
- X-Ray hour meter (generator meter)
- Generator and tube ID codes
- System mode code (shows X-Ray Off, On or Ramping)
- kV and mA at time of event

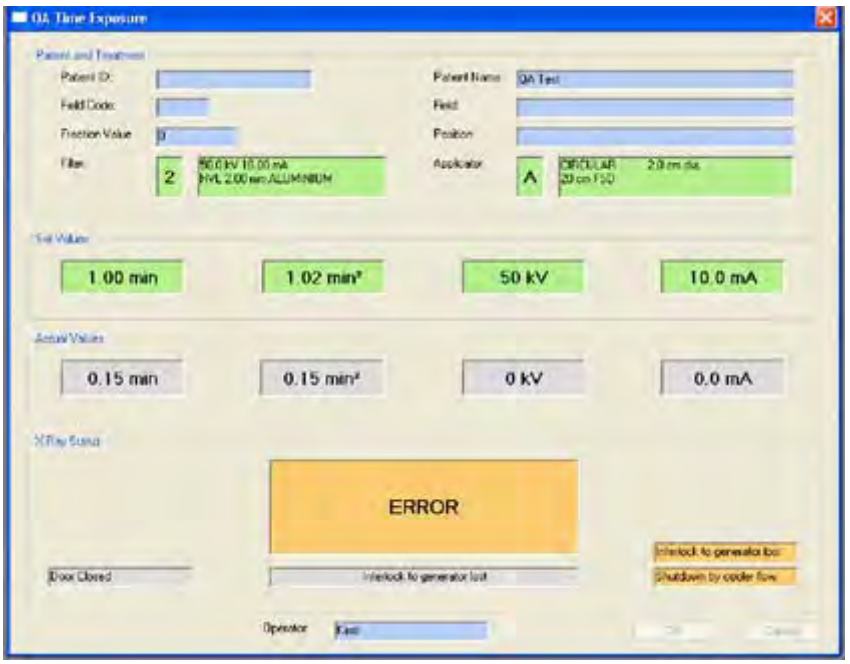
3.5 Help

Figure 3–57: Help About

The Help About screen provides information about the software version and licensing.

3.6 System Errors and Interlocks

Figure 3–58: QA Time Exposures



Any system error occurring in the TP2 or the generator which cause an interruption or prevention of the exposure is recorded in a log. If there are multiple errors, the log will only record the first error.

Errors occurring as orange interrupt messages in the (bottom right) window.

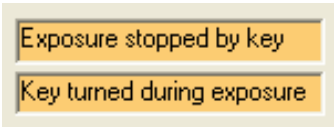
Note: Errors are recorded as numerical codes. Please see the Error Code table in Appendix C at the back of this manual. .

Some errors are recorded through procedural or power failure. *For example*, If the TP2 filter or applicator selection is changed after an exposure has been applied to the exposure control window, then a filter/applicator encoding error will appear. It is not possible to continue with the exposure until the correct filter or applicator is refitted.

If power is lost during treatment, a power lost error will be recorded.

If the key switch on the TP2 operator pod is turned to standby (position 2) during an exposure, the following standby error will appear:

Figure 3–59: Standby Error

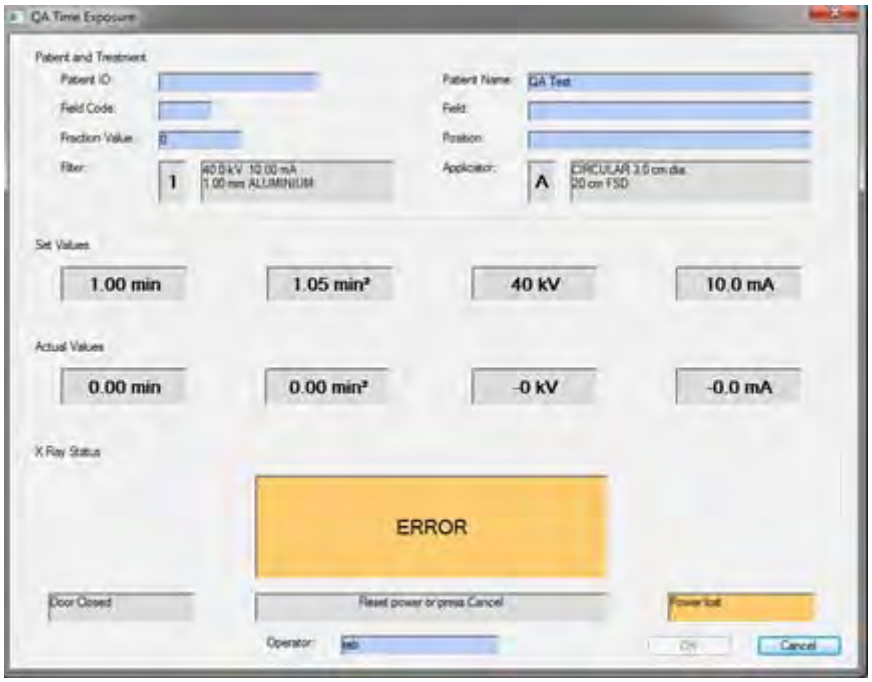


Continue the exposure after a *Standby* error:

1. Turn the key switch to *HT* (position 3)
2. Press the green *X-Ray On* button

Active system interlocks (*for example*, the treatment room door) prevent *X-Rays On* from switching on. Active interlocks appear as blue system messages (bottom left). All active interlocks must be satisfied before *X-Rays On* will activate.

Figure 3–60: QA Time Exposure



Section 4:

Time/Dose Control System

in this section

4 Time/Dose Control Systems

The TP2 is connected to the generator through a serial data connection. Both contain microprocessor controllers with real time clocks.

In *Time Control Systems*, the primary channel is performed by the generator controller and the secondary time channel is performed by the TP2. The time channels are constantly being checked to ensure their time increments are identical. In *Dose Control Systems*, the primary channel is the dose channel measured by pulses on the ionisation chamber.

The TP2 system has two time limits, primary and secondary time:

- The primary time in the TP2 is compared to the required treatment time to generate the treatment.
- The secondary time in the generator can be compared to a time limit, which is programmed to be the treatment time, plus 0.05 minutes (dose mode is + 0.05 minutes or + 5%, whichever is greater) and this will terminate the treatment if the primary time comparison fails.

4.1 Medical Start Up

To avoid ramp up errors which can occur at kV energies, the Xstrahl range of systems operate a medical start up in which the kV rises to 90% of the required full scale value before the mA starts to ramp or rise to its required value.

Once the mA ramp is 50% complete the treatment timer will start. This enables both the kV and mA to stabilise adequately and deliver a homogenous dose.

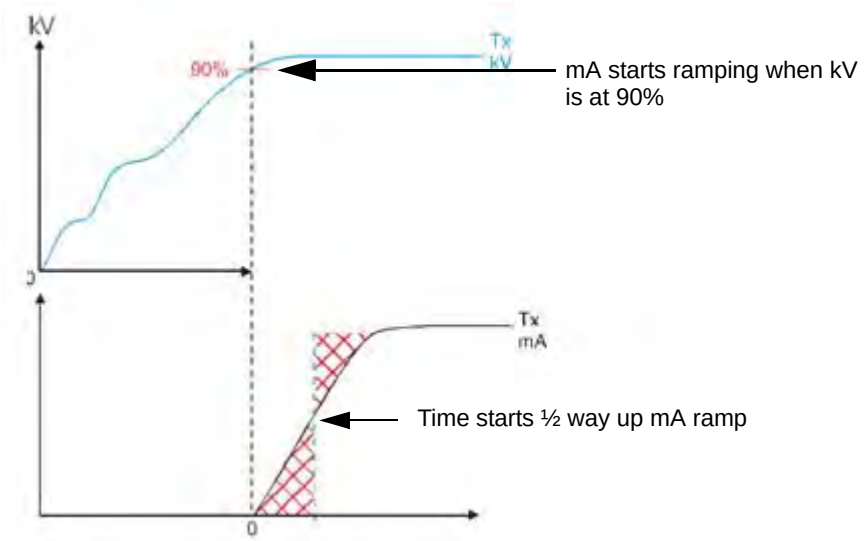
Note: Exposures must not be prescribed which are shorter in duration than the time it takes for the mA to ramp up to 50% of the full scale value.

for example

Using the FC100 generator as a reference model; the full scale mA is 25 and the full scale mA slew time is 16 seconds. This indicates the generator is capable of going from 0 to 25 mA in 16s. It will therefore take 6.4s to reach 10 mA and 10.24s to reach 16 mA.

If a treatment was to be delivered at 16 mA, it must not be less than 5 seconds in duration because this would mean the exposure was delivered in the mA ramp.

Figure 4–1: kV Ramps to 90% of Full Scale Value

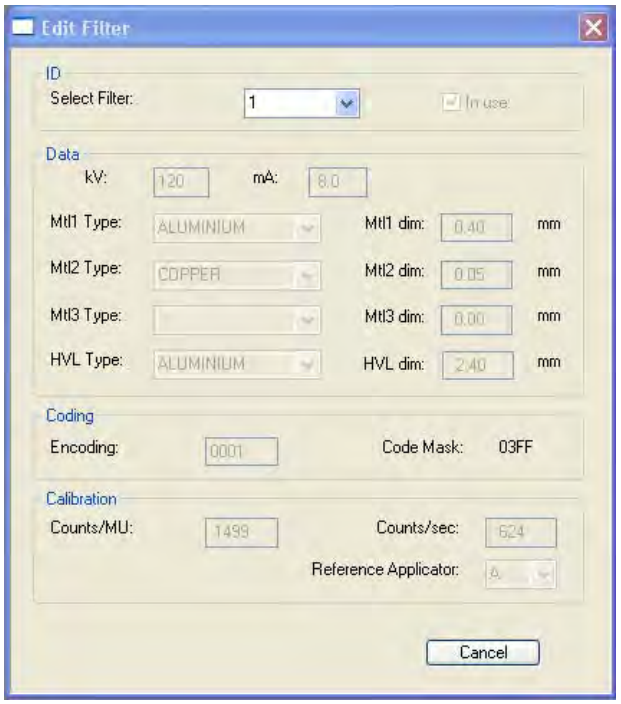


The above illustration demonstrates the mA starting when the kV is at 90% of the required value, which means the kV will have stabilized before the mA starts to ramp.

If the clinical exposure is very short in duration, the operator should reduce the mA value.

4.2 Filter Data

Figure 4–2: Fisica Edit Filter Window



Fisica filters are defined within the software. The Xstrahl system comes standard with a set of filters unless specific filter compositions were ordered at the initial point of sale. The *filter identity signals* from the wall-mounted filter box are connected to the TP2 CPU PCB. Filter fitted signals are also connected this way. The configuration of the filters can be edited within the *Edit Filter* function.

To edit a filter:

1. Select *Edit*, then Filter[1]
2. Select the required filter
3. Select *Edit*

1. Only a Physics Supervisor level user is permitted to change the filter settings.

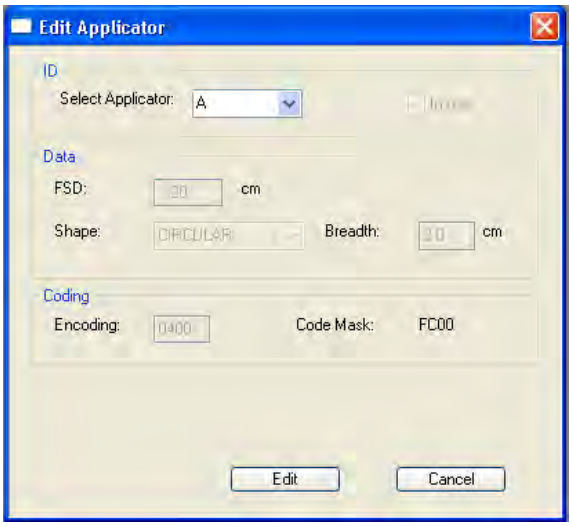
4.3 Filter Storage

The treatment filters are housed in a wall mounted storage unit. Each individual filter holder can only reside in its own unique place in the storage box due to the physical shaping of the storage unit and the filter holder. The filters clicks into place when fully inserted into any holder.

Figure 4–3: Filter Storage Unit

4.4 Applicator Data

Figure 4–4: Fisica Edit Applicator Window



The applicators are defined within Fisica, as demonstrated above. The system will be installed with a standard set of applicators, unless specific applicators were ordered.

The applicators can be edited within the *Edit Applicator* function. The applicators are not interlocked within the sub-tube assembly.

To edit an applicator:

1. Select the *applicator* (by letter A-Z) from the ID field menu.
2. Select *Edit* to activate the applicator parameters

3. Select (or deselect) the *in use* box to enable applicators for clinical use. Only *in use* applicators are available for QA exposures and patient treatment.
4. Select *Save*. Select *Undo Changes* to undo edits prior to saving.

4.5 Acceptance and QA

The Xstrahl 200 can define the exposure in time and dose mode. The output at each clinical energy needs to be measured during the acceptance of the unit and schedule in the daily quality assurance (QA) conducted on the machine.

In dose systems, each filter must be calibrated with a reference applicator before using, then each applicator required to be used with each filter must also be calibrated before it can be used clinically. Every filter and applicator combination which is required for clinical use must be calibrated.

The IPEM report 81, kilovoltage X-Ray units recommends the following quality control checks are conducted on superficial systems

Recommended Quality Control Checks[a]		
	Test Frequency	**Tolerance**
Daily	Output constancy check	± 5% if the daily output constancy check varies by more than ± 5% from the previous monthly output calibration, an investigation should be performed. This should include at least a measurement of HVL.
	Interlocks and warnings	*
	Mechanical fixtures	*
	Filter interlock	*
Weekly (or following repair)	Filter interlock	*
Monthly (or following repair)	Output measurement	± 3%
	Timer accuracy	± 0.01 min
	Filter interlocks	*
	HVL constancy	± 10%
Annually (or following repair)	Field uniformity	± 2%
	Half value layer	± 10%
	Focal spot alignment	*

a. Refer to IPEM (Institute of Physics and Engineering Medicine) report 81 for further details on recommended quality assurance checks.

4.6 Monitor Unit Calibration

For a dose based system, there is an in-line ionisation chamber fitted into the tube head assembly, perpendicular to the X-Ray beam. When the beam is turned on, the ion chamber charge plates are used to collect point charge. This charge creates a small current which the electrometer uses to initiate dose pulses or counts. This is dependent upon kV, mA and material settings. These counts are fed back to the TP2 and during filter calibration, can be viewed live at the top of the exposure screen.

At the end of calibration, the software calculates the number of counts/MU and counts/sec from this field and the actual dose is entered by the Physicist. Xstrahl recommends that 1 cGy = 1 MU.

The actual counts/MU value stored is counts per 1/10th of an MU, rather than per MU in order to ensure the best possible resolution for the TP2 hardware.

Section 5:

X-Ray Tube, Filters and Applicators

in this section

5 X-Ray Tube, Filters and Applicators

5.1 Xstrahl 200

The Xstrahl 200 system is designed to be used from 20 kV to 220 kV with 0 to 30 mA. The maximum output is 3000 watts, hence at 220 kV the maximum mA is 13.5 mA. The system is supplied with a dose control system (time based systems can be supplied). Further details on the dose control system can be found in the *Time/ Dose Control System* section of this manual.

The X-Ray tube assembly consists of a unipolar X-Ray tube of advanced metal-ceramic design with an integrated high voltage receptacle and cooling system. It is enclosed in shielded housing with fittings for warm hose connections. Further details on the cooling system can be found in the *Water Cooling System* section of this manual.

The Xstrahl 200 unit comes as a floor/wall mounted tube stand or a ceiling track mounted stand. Further details on the tube stands can be found in the *Xstrahl Tube Stands* section of this manual.

5.2 X-Ray Tube Technical Data

X-Ray Tube Technical Data[a]	
Focal spot size (EN 12543)	7.5 mm (largest dimension)
Maximum operating voltage	225 kV
Maximum tube power, continuous	3000 W
Maximum filament current	4.2 A
Maximum rating, continuous	225 kVp/13 mA
Field coverage, total	40º
Anode angle	30º
Target material	Tungsten
Inherent material	0.8 ± 0.1 mm Be
Weight	11 kg
Cooling, min, water flow	4 litres/min
Maximum water inlet temperature	35º C
Maximum water pressure	6 bar
Radiation leakage, max (Leakage statement taken from BS EN 60601-2-8: 1997)	< 1m Gy/h^{-1} averaged over 100 cm^2 ≤ 150 kV < 10 m Gy/h^{-1} averaged over 100 cm^2 > 150 kV

a. X-Ray tube only

5.3 Filters and Applicators

The Xstrahl 200 system can have an HVL of up to 2.5 mm of copper.

The Xstrahl 200 is supplied with the following standard filters and treatment applicators:

Standard Treatment Filters									
Filters	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
kV	40	60	80	100	120	150	180	200	220
HVL (mm)	1.0 Al	1.5 Al	2.5 Al	3.0 Al	5.0 Al	6.0 Al	0.5 Cu	1.0 Cu	2.0 Cu
Added filtration (mm)	0.8 Al	1.0 Al	2.0 Al	2.0 Al	0.5 Al 0.10 Cu	1.0 Al 0.10 Cu	1.5 Al 0.15 Cu	1.0 Al 0.45 Cu	1.0 Al 0.25 Cu 0.45 Sn

Applicators are manufactured from copper and have a clear Perspex® viewing end. The applicator concentricity is ± 1 mm.

The following table displays the filter encoding for the Xstrahl 200 filters, with switch 16 being the filter fitted switch:

Figure 5–1: Xstrahl 200 Filter Encoding Table

		0 1	1 2	2 4	3 8	4 16	5 32	6 64	7 128	8 256	9 512	10 1024	11 2048	12 4096	13 8192	14 16384	15 32768		
		SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8	SW9	SW10	SW11	SW12	SW13	SW14	SW15	SW16	VALUE	HEX
FILTER MASK		1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1023	3FF
APPLICATOR MASK		0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	64512	FC00
D3150 MASK		1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	33791	83FF
Filter	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
	5	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
	6	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6
	7	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7
	8	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	8	8
	9	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	9	9
	10	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	10	A
Applicator	A	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1024	400
Applicator	B	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2048	800
Applicator	C	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	3072	C00
Applicator	D	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4096	1000
Applicator	E	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	5120	1400
Applicator	F	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	6144	1800
Applicator	G	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	7168	1C00
Applicator	H	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	8192	2000
Applicator	I	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	9216	2400
Applicator	J	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	10240	2800
Applicator	K	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	11264	2C00
Applicator	L	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	12288	3000
Applicator	M	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	13312	3400
Applicator	N	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	14336	3800
Applicator	O	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	15360	3C00
Applicator	P	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	24576	6000
Applicator	Q	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	25600	6400
Applicator	R	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	26624	6800
Applicator	S	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	27648	6C00
Applicator	T	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	28672	7000
Applicator	U	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	29696	7400
Applicator	V	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	30720	7800
Applicator	W	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	31744	7C00
Applicator	X	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	57344	E000
Applicator	Y	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	58368	E400
Applicator	Z	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	59392	E800
D3150 Filter	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	32769	8001
D3150 Filter	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	32770	8002
D3150 Filter	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	32772	8004
D3150 Filter	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	32776	8008
D3150 Filter	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	32784	8010
D3150 Filter	6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	32800	8020
D3150 Filter	7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	32832	8040
D3150 Filter	8	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	32896	8080
D3150 Filter	9	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	33024	8100
D3150 Filter	R	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	33280	8200

5.4 Applicator Field Sizes (FSD)

The standard set of applicators are supplied at 2 FSD's and cover the following range of field sizes:

Standard Applicator FSD Sizes	
20 cm FSD Open Applicators	**50 cm FSD Open Applicators**
3 cm diameter	4 cm x 4 cm
4 diameter	6 cm x 6 cm
5 diameter	8 cm x 8 cm
10 cm diameter	10 cm x 10 cm
	15 cm x 15 cm
	20 cm x 20 cm

Additional applicators are available allowing up to a total maximum 26.

The maximum field size which can be achieved:

- 20 cm FSD maximum applicator size of 8 cm x 8 cm (11 cm diameter)
- 50 cm FSD maximum applicator size of 20 cm x 20 cm (28 cm diameter)

5.5 Cleaning the Applicators

CAUTION: Due to the ends of the treatment applicators being constructed of Lucite® (Perspex®), it is not recommended that products with high quantities of alcohol be used to clean the applicators after use. Using alcohol will result in the Lucite end tips becoming cloudy and cracked in appearance.

The applicator manufacturer recommends a product free from alcohol be used to clean the applicators, such as Sterets Unisept®, a sterile aqueous solution containing chlorhexidine gluconate 0.05% w/v.

If you have any queries regarding the suitability of various cleaning products, please contact Xstrahl Limited before using on the applicators.

Section 6:

HT Generator

6 HT Generator

PROTECTIVE EARTH: Protective earth labels are placed next to protective earth terminal studs. Ensure earth terminals are connected to system earth at installation and before operating the equipment. If any protective earth point is disconnected, the equipment must not be used.

For further information on the Xstrahl 200 generator, refer to the *CP Series Technical Manual* included with this manual.

The CP Series Technical Manual provides the following information:

- Introduction
- Warnings
- Safety Procedures
- Specifications
- Installation
- System Description
- Converter Circuit
- X-Ray Control PCB
- IGBT Controller PCB
- IGBT Drive and Sense PCB
- Heat Sink Sense PCB
- Dual Regulated Filament/Feedback PCB
- Cathode Generator Tank
- Anode Tank
- Field Adjustments
- Filament Preheat
- Filament Limit
- Troubleshooting
- Removing the Converter Chassis
- Recommended Spare Parts

Section 7:

Xstrahl 200 Tube Stands

in this section

7 Xstrahl 200 Tube Stands

CAUTION: The stand ropes in both the floor/wall and ceiling stands must be changed every five years as per the manufacturer's instructions and should only be carried out by trained personnel. A record of the rope change should be retained for future reference.

The Xstrahl 200 systems are supplied as either a floor/wall mounted tube stand or a ceiling track support system.

All of the stands have electromagnetic brakes. The operator selects the movement required by pressing the movement buttons (illuminated). The movement brake is released when the operator selects the movement enable buttons. Releasing the movement enable button will lock the brake.

In the event of a power failure, the vertical brakes on all the systems will fail safe and lock; the other movement brakes will be released to allow the system to be moved away from the patient.

Comparison of Available Tube Stands			
	Floor/Wall	**Column Floor**	**Ceiling**
Xstrahl 200	√	x	√

7.1 Xstrahl 200 Floor/Wall Stand

Figure 7–1: Xstrahl 200 kV Floor/Wall Stand

The Xstrahl 200 floor/wall stand enables positioning of the tube in three axes; vertical, lateral and longitudinal, together with the ability to rotate the sub-tube assembly. The vertical mast is supported on a floor mounted rail, which permits horizontal positioning. The top of the vertical mast is supported by a further rail which can be mounted on either a wall or ceiling

Instructions for the use of the tube stand brakes and rotational movements for each machine can be found in the *Xstrahl 200 Operator Manual*.

7.1.1 Technical Specifications (Floor/Wall)

Technical Specifications: 200 Floor/Wall Stand	
Length of longitudinal aluminium rails	4000 mm max
Longitudinal travel	2800 mm max
Transverse travel	200 mm max
Vertical Travel	1500 mm max
Minimum distance tube axis to floor	500 mm
Counter-balancing system	Adjustable counterweights
Maximum weight supported	42 kgs
Movement brakes	Electromagnetic
Maximum vertical movement with power loss	1 mm
Brake control	Select movement enable buttons on the tube front cover
Electrical power requirements	220 VAC ± 10% single phase 50/60 Hz, 200 VA
Paint finish	RAL 9002
Net weight	160 kg
Ceiling height for ceiling fixing of support rail	2.5 to 3 m

7.2 Ceiling Track System

Figure 7–2: 200 kV Ceiling Track

The Xstrahl 200 system can be mounted onto a ceiling track support system. Ceiling track mounted units have an additional movement—rotation about the vertical mask. All other movements remain and are controlled by selecting the movement brake, followed by the movement enable button.

7.2.1 Technical Specifications (Ceiling Track)

Technical Specifications: 200 Ceiling Track	
Degree of rotation of tube assembly around horizontal arm	270º (± 135º)
Rotation positioning detents	every 90º
Degree of rotation of tube assembly (axial rotation)	90º (+60º to -30º)
Ceiling Rails:	
Standard length of longitudinal aluminium rails	4400 mm
Longitudinal travel	3600 mm
Standard length of transverse aluminium rails	3000 mm
Transverse travel	2280 mm
Covered area	4260 x 4290 mm
Distance from X-Ray beam centre to vertical column axis	380 mm
Number of extruded aluminium telescopic sections	4
Vertical travel	1500 mm
Counter-balancing system	Tensator® spring and counterweights
Maximum weight supported	75 kgs
Movement brakes	Electromagnetic
Brake control	Select and movement enable buttons

7.3 Power Loss

7.3.1 Ceiling Track

In the event of a power loss or when the main power is switched off, the brakes which control the lateral and longitudinal movements of the tube support along the ceiling rails will be freed, enabling the machine to be moved away from the patient. The vertical brake is a fail-safe mechanism and will not release.

7.3.2 Floor Stand

In the event of a power loss or when main power is switched off, the vertical movement will be locked and the brakes controlling the longitudinal and lateral movements will be freed, enabling the machine to be moved away from the patient.

The vertical brake is a fail-safe mechanism and will not release.

7.3.3 Manual Vertical Override

In the event of an emergency, it is possible to manually override the vertical movement by pushing the tube head vertically up the telescopic column (ceiling stand) or the floor stand column. It is only possible to push the tube up; the magnetic braking system will prevent the tube head coming down either automatically or manually.

WARNING: To ensure safety, push the bottom of the vertical column (ceiling track) or the bottom of the horizontal arm (floor stand) and not the tube head. The tube assembly may be heavy, especially with a large applicator fitted, so observe all local manual handling procedures if performing manual height overrides.

7.4 Cleaning

WARNING: When cleaning with disinfectants, do not use agents that when mixed with air produce flammable or explosive vapours. This equipment should not be subjected to liquid spills or ingress of liquids or harmful substances. Follow the manufacturer's instructions for use supplied with your chosen cleaning agent or disinfectant.

Carry out cleaning and disinfecting as required. Always clean the equipment with the main power is switched off. Dust metallic parts as required. If soiling or more stubborn stains exist, use a non-abrasive cleaning agent and apply with a damp, *not wet*, cloth.

7.5 Maintenance

To ensure continued safety and optimum performance, it is necessary to have periodic inspections and maintenance carried out on this equipment by a suitably trained and authorised service engineer.

Section 8:

Water Cooling System

8 Water Cooling System

The Xstrahl 200 offers two types of closed circuit water coolers:

- An *air blast water cooler*, whereby the water is cooled through a heat exchanger/radiator system; the water cooling is assisted by a thermostatically controlled fan
- A *water/water cooler*, whereby the water is cooled through a heat exchanger by a thermostatically controlled cold/chilled water system. The water/water cooler consists of two separate water loops; one pumps the water, under pressure, around the closed loop of the X-Ray tube and the other supplies cool or chilled water to the heat exchanger loop in the water/water cooler before either being re-circulated in the local chilled supply or lost through a drain (model no.).

The interface connector and mains cable is connected to the TP2 CCU, which provides the power supply and the interlocking of the water cooler. When the water in the closed loop reaches a temperature determined by the control thermostat, the thermostat will, depending on cooler type, either operate a relay to control the fan for the air blast or open a solenoid, which controls the flow of the cold/chilled water. There is a flow switch, which is set to the requirements of the installation site and conditions, which provides cooler interlocking on a failure of the water/water cooler pump or power supply.

There is also an over temperature switch that trips the interlock if the water temperature exceeds 35ºC.

Note: Refer to the respective cooler unit supplier manual provided with your Xstrahl system.

8.1 Specifications

Xstrahl 200 Water Cooling Specifications	
Cooling capacity	3 kW (dependent on incoming coolant temperature)
Coolant flow rate	4 litres/min at 3.5 bar
Coolant	20 litres water with a 30% glycol mix
Cooling water pressure	Max 8 bar
Controls	Over temperature thermostat set at 35ºC; flow switch: 4 litres/min minimum
Water connections	Flow 3/8 BSP male parallel connected to 12 mm bore flexible hose coupling; return 3/8 BSP male parallel connected to 12 mm bore flexible hose coupling

Xstrahl 200 Water Cooling Specifications	
Customer connection	Water/water cooler only—plumbing work required for incoming water supply with hose tails to accept 1/2 inch reinforced hose
Controls	Wired out to terminal blocks inside cooler; all connections enclosed
Electrical supply	220 volt ± 10%, 3.8 A single phase 50/60 Hz, 3 wire, live, earth, neutral and system interlock cables
Vibration mounts	Pump and heat exchanger mounted on anti-vibration

Note: Refer to the specific cooler manual for detailed technical information.

Appendix A:

Xstrahl Preventive Maintenance Procedures

NOTE: It is recommended that Preventive Maintenance (PM) be completed once every *six* calendar months.

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Xstrahl Preventive Maintenance Procedures

Xstrahl System:	
Serial Number:	
Hospital/Site:	
Date:	
Service Report Number:	
Test Equipment Serial No.:	

Procedure	**Initial**
Pre-Service Checks:	
Whilst with the customer, ensure the system is functioning without error by asking the customer to conduct a QA exposure.	
Obtain the handover signature from the customer.	
Download and view the TP2 and Generator Log files.	
Save the Log files: File Name: site, (TP2/Gen), Date	
View Log files and note any errors that need to be raised with the customer: • TP2 errors • Generator errors	
Interlocks and Indicators	
Power Off—Check display on LCD power fail display	
Power On the Xstrahl System to Standby and check the following:	
• That the mains CCU indicator is illuminated.	
• That there are seven (7) green LED indicators on the CPU.	
• Remove Cooler Mains Connector (GLAND_3). **Log on to Fisica as an Engineer and:** 1. Select Tools ➢ QA Exposure 2. Select a Filter/Applicator/mu (or time) 3. Start an exposure. Check for cooling system error message; *No Cooler Flow* is displayed.	
Reconnect Cooler Mains Connector; re-apply the exposure, ensure the error message clears and *Ready* status is displayed.	
While still in *Ready* status (not X-Rays ON), check that the Interlocks function correctly.	
Pod Emergency Stop Press Emergency Stop and record the errors displayed:	
Release the Emergency Stop; ensure errors are cleared and *Ready* status is displayed.	

Interlocks and Indicators	
Room Interlock Procedure: 1. Press the room Interlock button. 2. Record the Interlock message displayed on the screen.	
Release Interlock; ensure Interlock message clears and *Ready* status is displayed.	
Door Interlock including *Last Man Out* or *Dual Door.*	
Open the treatment room doors when the unit is in *Ready* status and ensure the room door Interlock is displayed.	
Close the door and ensure the Interlock clears.	
Check the *dual door* Interlock function if present.	

Warning Lights	
Disconnect the warning light interface cable from the CCU gland plate; then press *X-Ray ON.*	
Check *X-Ray ON light failed* error is displayed.	
Reconnect warning light interface cable and ensure the error clears and X-Rays can be started.	

Pod Functions	
Ensure the following function correctly:	
• X-Ray ON button	
• X-Ray OFF button	
• Key switch Standby HT—Position 1 and 2	
• Key switch Standby HT—Position 3 (*key cannot be removed*)	
• Warning buzzer heard	
Run a QA exposure: 1. Exit Fisica 2. Power Off the system. 3. Turn the pod off (check LCD on CCU is displaying MT and continues to do so for the cooler run on time). MT is only displayed if the time since the last exposure has not elapsed during Power On.	

Cooling System	
Remove the cooling system cover and if fitted, check the strainer. Clean and replace.	
Clean the cooler fan and radiator if applicable.	
Check the coolant level; top up if necessary.	

Cooling System	
Check tightness of hose clamps and connections.	
Check for leaks from joints/hose connections.	
Visually inspect hoses for signs of wear or damage.	
Airblast only cooler; check the function of fan control thermostat by adjustment.	

CCU	
Ensure connectors on the gland plate are secure.	
Ensure cables are securely clamped in plug housings.	
Ensure PCB mounting is secure and all edge connectors are secure.	
Ensure LCD is secure and ribbon cable undamaged.	
Open *Inner Door*; check all clamps, terminals and connectors are secure.	

<table>
<tr><th colspan="2">Sub-Tube Assembly</th></tr>
<tr><td>Visually inspect and check operation of filter and applicator recognition switches.

In Fisica:

View TP2 status—the Application/Filter bit values should be checked and recorded as follows:

<table>
<tr><th colspan="2">Filter</th><th colspan="2">Applicator</th></tr>
<tr><td>1</td><td></td><td>A</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
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</td><td></td></tr>
<tr><td>Confirm all filters fit correctly; check for any damage to the filter materials.</td><td></td></tr>
<tr><td>Check the filter holders for damage/wear, paying attention to recognition holes and security of screws.</td><td></td></tr>
<tr><td>Confirm applicators fit and lock correctly (adjust door lock as necessary).</td><td></td></tr>
<tr><td>Check applicators for damage/wear, paying attention to coding rings.</td><td></td></tr>
<tr><td>Check the tightness of the main protective earth cable on the sub-tube assembly rear.</td><td></td></tr>
<tr><td>Visually inspect the filter/applicator interlock cable connections at the rear of the sub-tube assembly.</td><td></td></tr>
<tr><td>Visually inspect the ion chamber within the sub-tube assembly (where fitted) and the cable connections at the rear.</td><td></td></tr>
</table>

Sub-Tube Assembly	
Check tightness of hose connections at X-Ray tube hose fittings.	

HT Cable Compression: Power System Down	
Ensure the anti-tamper labels are still in place at both ends of the HT cable(s).	

X-Ray Tube End	
Where necessary, disconnect water hoses and associated cables to enable release of the HT cable, including earth termination where applicable.	
Measure the screen resistance of the HT cable (1Ωm).	
Remove old grease from cable ends and receptacle; clean using IPA (Isopropanol Alcohol) and a clean lint free cloth.	
Renew grease and reconnect HT cable; check for a 4 mm–6 mm gap, fit screws and tighten in turn using opposites.	
Power On and conduct a short exposure to ensure no error messages.	
Re-secure flange screw following cable compression.	
Power down and allow 5 minutes to dissipate.	

HT Generator	
Release HT cables (anode and cathode).	
Clean, re-grease and gap as per tube end using the following gap guide: • 100, 150 and 300 generators 4–6 mm gap • 225 generators 5–7 mm gap	
Fit screws and tighten in turn using opposites.	
Power On and conduct a short exposure to ensure no error messages.	
Re-secure flange screw following cable compression.	
Power system down.	
Fit new anti-tamper labels to the HT connections at both ends of the HT cable(s).	

CP HT Generator	
With the system still powered down, remove the top cover to the cathode generator and clean all cooling fans and grills of dust.	
Carry out a visual inspection of the converter chassis, checking the connection of cables to PCBs.	
Replace cover; replace and check tightness of cable connectors to cathode generator (and anode).	
Check *protective earth cable* connection tightness to cathode (and anode).	

Earth Reference Terminal	
Ensure tightness of all connections.	
Measure resistance from major parts of the Xstrahl system to the earth reference terminal (<0.1 Ω).	
Measure the earth leakage current between the main earth connection and earth reference terminal (<5.0 mA)	
Reconnect the main earth connection after measurement.	

Tube Stand	
Remove covers where necessary and clean all electromagnetic brake tracks.	
Power On the system to power the tube stand. Ensure correct functioning of movement; select and actuate switches.	
Check the movement of the axial tube rotation worm, wheel and movement locking brake: • Axial gearbox and brake handle. • Anterior/posterior gearbox and brake handle. • 150 (vernier rotation handle).	
Carry out a visual inspection of the cable support system and telescopic column, including the vertical movement fail-safe mechanism.	
Sign and date annual inspection rope sticker on the tube stand.	
Note the scheduled rope change date.	

System Checks	
Conduct a short warm up on the system.	
Conduct a 1 minute QA exposure at each energy level to ensure correct system operation.	
Reset the Fisica *Engineering Screen* Maintenance Date, Record Date Set: __ __:__ __:__ __	
Record the X-Ray On Hours Value in the Fisica Engineering Screen: __ __:__ __:__ __	

System Checks	
Xstrahl non-conformity comments	
Remedial action	
Follow-up	
Service Engineer:	
Customer Representative:	
Date:	

—blank—

Appendix B:

Error Code Table

Error Code Table		
No.	**Message Displayed**	**Description**
2	Division by zero	Displayed if an internal computation results in a division by zero. Requires power to be recycled.
3	Divide overflow	Displayed if an internal computation results in a division of zero. Requires power to be recycled.
4	kV too high	Generator error. Displayed when the generator kV exceeds the desired value. Latching error
5	mA too high	Generator error. Displayed when the generator mA exceeds the desired value. Latching error
9	Focal spot error	Generator error. Displayed after power up if the sense of a dual focal spot filament setting changes.
10	Bipolar status error	Generator error. Displayed after power up if the sense of an anode tank changes.
11	Generator over kV	Generator error. Displayed when the generator kV exceeds a value set in the combination of X-Ray tube and generator data. Latching error
12	Generator over mA	Generator error. Displayed when the generator mA exceeds a value set in the combination of X-Ray tube and generator data. Latching error
13	Converter current	Generator error. Displayed when an internal current limit is exceeded in the generator drive electronics. Latching error
14	Converter voltage	Generator error. Displayed when an internal voltage limit is exceeded in the generator drive electronics. Latching error
15	No cooler flow	Displayed when the coolant flow rate is less than the internal setting. Non-latching error; will reset automatically. This error disconnects the safety contactor.
16	Check cooling system	Displayed when the coolant temperature exceeds the internal cooler limit. Non-latching error; will reset automatically. This error disconnects the safety contactor.
18	kV too low	Generator error. Displayed when the generator kV fails to reach the desired value within a defined period of time. Latching error.
19	mA too low	Generator error. Displayed when the generator mA fails to reach the desired value within a defined period of time. Latching error.
22	X-Ray decay too slow	Generator error. Displayed if the decay of the kV at the end of the exposure takes too long. The system status will remain as X-Ray On until the kV threshold is reached.
24	Residual kV too high	Generator error. Displayed if the generator kV exceeds a certain value in X-Ray Off.
25	Residual mA too high	Generator error. Displayed if the generator mA exceeds a certain value in X-Ray Off.
27	Communication delay	Displayed if the communications from the generator fails. This will inhibit or terminate X-Rays On

Error Code Table		
No.	**Message Displayed**	**Description**
28	All filters in box	Displayed when all *filters* are in the wall box when a *filter* is selected (only certain systems). Non-latching error; will reset automatically.
29	Two filters removed	Displayed when more than one *filter* is missing from the wall box when a *filter* is selected (only certain systems). Non-latching error; will reset automatically.
30	Please fit filter	Displayed when no *filter* is fitted to the sub-tube assembly when a *filter* is selected. Non-latching error; will reset automatically.
34	Bipolar kV matching failure	Generator error. Displayed in bipolar systems when the anode and cathode kV measurements differ by a defined amount. Latching error.
35	Bipolar mA matching failure	Generator error. Displayed in bipolar systems when the anode and cathode mA measurements differ by a defined amount. Latching error
36	Feedback open circuit	Generator error. Displayed whilst the connection to the control PCB from the filament feedback PCB is open circuit (CP Models).
37	Heatseat sink temperature	Generator error. Displayed whilst the heatseat sink thermostat indicates a high temperature.
38	High calibration error	Generator error. Displayed when the value of calibration voltage entered in an initializing process is too high.
39	Low calibration error	Generator error. Displayed when the value of calibration voltage entered in an initializing process is too low.
40	Anode over mA	Generator error. Displayed in bipolar systems when the anode tank mA exceeds the desired value. Latching error
41	Anode under mA	Generator error. Displayed in bipolar systems when the anode tank mA fails to reach the desired value within a defined period of time. Latching error
42	Less than 5 kV reached	Generator error. Displayed when the generator fails to reach 5 kV within a defined period of time after receiving an X-Ray On command. Latching error
43	Interlock to generator lost	Generator error. Displayed when an exposure is terminated by the removal of the interlock input to the generator. Latching error
45	Prohibited exposure	Displayed when the time entered in a *Time* treatment exceeds the set time limit. This error will persist until a compliant time is entered. (can be caused in a *Dose* treatment)
46	Uninitialised filter	Displayed when an uninitialized *filter* is selected or zero values detected for any of the following: kV, mA, HVL, Type HVL, Dimension or encoding.
47	Bad applicator data	Displayed when an uninitialized applicator is selected; non-valid shape or zero values in any of the following: width, breadth for rectangular applicator, length or encoding.
48	Bad dose calibration	Displayed when a *filter* is selected for a dose exposure with a non-valid reference applicator or zero values for counts/second or counts/MU.
49	Exposure not entered	Displayed when the X-Ray button is pressed and the internal NEEDS status indicates the *exposure* is not set. This error will persist until another treatment is set.
50	No filter selected	Displayed when the X-Ray button is pressed and the internal NEEDS status indicates the *filter* is not set. This error will persist until another treatment is set.

Error Code Table		
No.	**Message Displayed**	**Description**
51	No applicator chosen	Displayed when the X-Ray button is pressed and the internal NEEDS status indicates the *applicator* is not set. This error will persist until another treatment is set.
52	Bad temperature	Displayed when the temperature (in degrees centrigrade) read from the transducer is less than a *minimum* (10) or greater than a *maximum* (35). *Dose systems only*. This error will persist whilst the temperature is invalid.
53	Bad pressure	Displayed when the pressure (in milli-bars) read from the transducer is less than a *minimum* (700) or greater than a *maximum* (1200). *Dose systems only*. This error will persist while the pressure is invalid.
55	X-Ray Off signal open to power up	Displayed if the X-Ray Off button is open-circuit at power up.
56	Shutdown by safety1	Displayed if the X-Ray beam is stopped by the door contact being open. Latching error requires a new X-Ray On signal to be reset.
57	Shutdown by safety2	Displayed if the X-Ray beam is stopped by the second door/room interlock contact being opened. Latching error requiring a new X-Ray On signal to be reset.
58	Shutdown by cooler flow	Displayed if the X-Ray beam is stopped by the cooler flow contact being opened. Latching error requiring a new X-Ray On signal to be reset.
59	Shutdown by cooler temp	Displayed if the X-Ray beam is stopped by the cooler temp contact being opened. Latching error requiring a new X-Ray On signal to be reset.
60	Contactor closed at power up	Displayed at start-up if the *safety* contactor is engaged but not enabled.
64	System has RESET	Generator error. Displayed if the processor in the generator has reset.
66	Key turned during exposure	Displayed if the X-Ray beam is stopped by the control pod key being moved from *HT* (position 3), the X-Ray enable position. Non-latching error
67	High kV demand in Xoff	Generator error
68	High mA demand in Xoff	Generator error
71	Droop cal. too high	Generator error
72	DAC offset too high	Generator error. Displayed if the *digital* to *analog converter* (DAC) offset voltage is too high. This will inhibit an exposure.
73	DAC range problem	Generator error. Displayed if the *digital* to *analog converter* (DAC) range data is incorrect. This will inhibit an exposure.
74	ADC zero offset too high	Generator error. Displayed if the *analog* to *digital converter* (ADC) offset voltage is too high. This will inhibit an exposure.
75	ADC range problem	Generator error. Displayed if the *analog* to *digital converter* (ADC) range data is incorrect. This will inhibit an exposure.
76	ADC calibration lost	Generator error. Displayed if the *analog* to *digital converter* (ADC) calibration is lost. This will inhibit an exposure
77	Bad generator table in PROM	Generator error. Displayed if the generator type data is corrupt. This will inhibit an exposure.

Error Code Table		
No.	**Message Displayed**	**Description**
78	kV breakdown lockout	Generator error. Displayed if the X-Rays have been terminated by three events at successively lower kV values. This will inhibit an exposure.
79	X-Ray Off I/O problem	Generator error. Displayed if the generator receives an X-Ray On initiation, but the X-Ray Off interlock line is not enabled (sourced with current).
80	Anode decay too slow	Generator error. Displayed in bipolar systems if the decay of the anode kV at the end of the exposure takes too long. The system status will remain as X-Ray On until the kV threshold is reached.
81	Interlock dropout	Generator error. Displayed if an exposure is terminated by the loss of the interlock signal. Latching error
82	Interrupted by HS temp	Generator error. Displayed if an exposure is terminated by the heatsink thermostat. Latching error
83	Not used	Generator error. Displayed if the *unipolar* or *bipolar* tables are incompatible.
84	Dual door interlock failure	Displayed if the two door sensors fail to operate together when configured to do so. This will prevent X-Ray On.
85	Overriding mandatory WU	Generator error. Not used in this system.
86	Exposure param error	Generator error
87	Anode residual kV	Generator error. Displayed in bipolar systems if the anode generator tank kV exceeds a certain value in X-Ray Off
88	Anode residual mA	Generator error. Displayed in bipolar systems if the anode generator tank mA exceeds a certain value in X-Ray Off.
89	No mA at switch On	Generator error. Displayed if the mA measured remains at zero after a specified time.
91	Shutdown by residual kV	Generator error. Latching error. Displayed if a residual kV error has terminated X-Rays.
92	Shutdown by residual mA	Generator error. Latching error. Displayed if a residual mA error has terminated X-Rays.
93	Timer interrupt late	Generator error
94	Generator not ready	Generator error
95	High energy discharge	Generator error
107	Generator interlock problem	Displayed if the control of the interlock relay does not result in the correct response from the generator.
108	App factor required	Displayed when the applicator is selected for a *Dose* exposure and the applicator factor for the selected applicator is out of range. (Must be greater than or equal to 0.8 and less than or equal to 1.2.)
109	Dose requested too high	Displayed when the dose entered in a *Dose* treatment exceeds the set dose limit. This error will persist until a compliant dose is entered.
110	LCD failure	Displayed if the TP2 fails to read data from the LCD. This error will persist until rectified.
111	Low dose rate error	Displayed when the dose rate monitored in a *Dose* treatment is less than the calibrated dose rate by more than 3%. The ratio of actual mA to desired mA will be used to modify the calculation on the switch on mA ramp. The error will terminate X-Rays. The error requires the control pod key to be counter-rotated to *Standby* (position 2) and then back to *HT* (position 3) to clear before X-Rays are enabled.

Error Code Table		
No.	**Message Displayed**	**Description**
112	Emergency Off	Displayed if the X-Ray beam is stopped by the Emergency Off button being pressed. X-Rays will not automatically resume after the Emergency Off has been manually reset, but may after the X-Ray On button is pressed.
113	Power On light failed	Displayed if the external Power On lamp fails to draw current. This will prevent X-Ray On.
114	X-Ray On light failed	Displayed if the external X-Ray On lamp fails to draw current. This will terminate X-Ray On.
115	Program not specified	Displayed when the X-Ray button is pressed and the internal NEEDS status indicates the program is not set. This error will persist until another treatment is set.
116	Exposure stopped by key	Displayed if the X-Ray beam is stopped because the control pod key has been moved from *HT* (position 3), the enable position. Latching error requires new X-Ray On signal to be reset.
117	Power lost	Displayed when the program monitoring the TP2 through the series communications fails to receive data. The program will indicate POWER LOST and wait for the TP2 to recover and, if possible, resume. Resumption of X-Rays will only be possible by operator control.
118	mA value not available	Displayed if the generator mA limit (for the desired kV) is less than the required *Treatment mA*. This will prevent X-Rays On.
119	kV value not available	Displayed if the generator kV limit is less than the required *Treatment kV*. This will prevent X-Rays On.
120	Stopped by backup timer	Displayed when the exposure is stopped by the backup timer. The calculation of the limit will vary between *Time* and *Dose* treatments. No further exposure is allowed. X-Rays On will be allowed, but termination will be repeated as soon as the timer starts.
121	High dose rate error	Displayed when the dose rate monitored in a *Dose* treatment is greater than the calibrated dose rate by more than 3%. The error will terminate X-Rays. The error requires the control pod key to be counter-rotated to *standby* (position 2) and then back to *HT* (position 3) to clear before the X-Rays are enabled.
122	Applicator encoding error	Displayed when the *applicator* bits do not match those of the specified applicator.
123	Filter encoding error	Displayed when the *filter* bits do not match those of the specified filter.
124	Generator not stopping	Displayed if the generator does not turn off within 2 seconds.
125	Generator not starting	Displayed if the generator does not turn on within 2 seconds.
127	Generator not set-up	Displayed if the generator cannot be set to the required kV or mA. This will prevent X-Rays On.
129	Maintenance due	Generator error. Displayed if the current date exceeds the date chosen for routine maintenance. Will not inhibit X-Rays On.
193	Generator interlock open	Displayed when the interlock to the generator is open; suppressed unless the interlock relay is enabled.
195	PC data interlock	Displayed when the TP2 fails to receive a software interlock from the PC at less than one second intervals with the control pod key in *HT* (position 3).
196	Door open	Displayed when the first safety signal is not sensed at the TP2. This error will disconnect the *safety contactor*.

Error Code Table		
No.	**Message Displayed**	**Description**
197	Room interlock open	Displayed when the second safety signal is not sensed at the TP2. This error will disconnect the *safety contactor*.
228	Watchdog failure	Displayed when the TP2 software fails to re-trigger the watchdog in time. The error is not resettable. *Fatal error*
229	Background lockup	Displayed when the TP2 background software fails to execute in time. The error is not resettable. *Fatal error*
234	Other trap	Displayed if an unexpected fault occurs. The error is not resettable. *Fatal error*
236	Bad code executed	Displayed if a bad instruction is detected. The error is not resettable. *Fatal error*
238	No real time clock	NOT USED
243	Processor clock fault	Displayed if an internal processor clock fault arises. The error is not resettable. *Fatal error*

Appendix: C

Notes

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