Thermo Scientific

MSA 330

Multi-Stream Analyser

Installation, Operation and Maintenance Manual

Doc No 01157 Rev 0

Part of Thermo Fisher Scientific

Thermo SCIENTIFIC

Thermo Scientific

MSA 330

Multi-Stream Analyser

Installation, Operation and Maintenance Manual

Doc No 01157 Rev 0

Thermo SCIENTIFIC

Thermo Fisher Scientific
Operating as:
Thermo Gamma-Metrics Pty Ltd
ABN 35 087 556 527
18 Butler Boulevard
Burbridge Business Park
Adelaide Airport, SA 5950
AUSTRALIA

Postal: PO Box 97, Export Park, Adelaide Airport 5950.
Telephone: +61 8 8208 8200
Fax: +61 8 8234 3772
E-mail: sales.auadl@thermofisher.com
Website: http://www.thermoscientific.com

European Contact

EU CE Contact: Hubert Sickmann
Frauenauracher Strasse 96
91056 Erlangen
Germany

Industry Canada ICES-003 Compliance to *CAN ICES-3 (A)/NMB-3(A)*

Occupational Safety and Health Act (OSHA)

The Occupational Safety and Health Act clearly places the burden of compliance on the user of the equipment and the act is generalized to the extent that determination of compliance is a judgement decision on the part of the local inspection. Hence, Thermo Fisher Scientific will not be responsible for meeting the full requirements of OSHA in respect to the equipment supplied or for any penalty assessed for failure to meet the requirements, in respect to the equipment supplied, of the Occupational Safety and Health Act, as interpreted by an authorized inspector. Thermo Fisher Scientific will use their best efforts to remedy such violation at a reasonable cost.

Document Information

Document Number	01157	
Author	Tejas Shah	
Technical Approval	Technical Lead, electronic	Tejas Shah
	Technical Lead, mechanical	Simon Liemar
	Technical Lead, System	Bryan Crosby
	Technical Lead, service	Michael Rose and Warrick Lee

Version History

Rev	Description	Revised by	Checked by	Date
0	Original Release		B Crosby, S Liemar, P Hayles and Alex Ratcliffe	Aug 2015

Where to find more information

For more information, service or spare parts for this product, contact:

Thermo Fisher Scientific
18 Butler Boulevard, Burbridge Business Park
Adelaide Airport, SA 5950, AUSTRALIA

Or

PO Box 97, Export Park, Adelaide Airport, SA 5950, AUSTRALIA.

Telephone: +61 8 8208 8200

Fax: +61 8 8234 3772

E-mail (parts): spares.auadl@thermofisher.com
E-mail (service): service.auadl@thermofisher.com

Web:[Minerals] http://www.thermoscientific.com/minerals

About this Manual

This Installation, Operation and Maintenance (IOM) manual contains technical information and procedures for operating and maintaining a Thermo Scientific Multi Stream Analyzer (MSA-330).

This version is based on the Thermo Scientific AM234 Multi Element Probe (MEP-300) incorporating a state of the art Silicon Drift Detector (SDD) that does not require liquid nitrogen and mechanical design as previous MSAs, however the electrical control panels have been re-designed in the interests of safety and segregation of voltages. All walk-in doors are now safety interlocked and re-starting after emergency stop or door-shut now complies with contemporary practice and international standards.

This manual contains information about the generic model MSA excluding any customizations that may have been included in a particular implementation. However other special requests like fiber optics comms is not covered. Keep in mind that the tank arrangement is always based on customer needs and can vary widely. All drawings and figures involving the stream/tank layout will be for the most common pattern.

The manual is organised into sections for easy accessibility by the personnel carrying out the work. Along with the essential safety-oriented chapters, several are written to be stand-alone for the purposes of installing, operating and maintaining the equipment. These are:-

Chapter 4 “Installation” covers activities associated with installing the equipment such as site preparation, utilities required, trade personnel requirements, mechanical and electrical installation, start-up and testing.

Chapter 6 “Calibration and Standardising” covers the calibration procedures for the equipment along with the associated standardizing process.

Chapter 7 “Operation” covers the day-to-day use of the equipment, including start-up, shutdown, and routine operational and maintenance checks.

Chapter 8 “Maintenance” covers mechanical, pneumatic and electrical service activities. Disassembly procedures are provided for repair and maintenance.

A separate stand-alone manual is provided for *WinISA*, the controlling software application that is supplied with the equipment. That manual is also provided electronically in PDF format on the WinISA CD supplied with the equipment.

Contents

List of Figures

List of Tables

Chapter 1 Warnings and Cautions

Read this section BEFORE attempting to operate the MSA.

This section describes the potential hazards associated with the MSA. You will see these symbols throughout this manual.

Warnings and cautions are identified by this symbol in the left margin:

Potential radiation hazards are identified by this trefoil symbol in the left margin:

Statutory Licensing Requirements

For protection of workers and the public, the use of radioisotope sources and radiation gauges is regulated by a government authority, which in all the States of Australia is the Department of Health or its equivalent. Similar regulations are in use in all countries and they are all based on recommendations of the International Atomic Energy Agency (IAEA).

Note The AM234 Multi-Element Probe (MEP) is classified as a Sealed Source *Radiation Gauge*. ▲

The onus is on the Customer to notify their local regulatory authority with details of the radiation gauges and radioisotopes to be used in their XRF analyzer system to ensure compliance. The regulations normally provide for the following matters:

1. Registration of ownership of each radioisotope used with the controlling regulatory authority.

2. Responsibility of the owner for maintaining records of radioisotope details including locality.

3. Responsibility of the owner for safe storage and safe usage of the radioisotope sources.

4. Nomination of one person as a Radiation Safety Officer (RSO) to carry out the nominated duties in relation to safe working practices.

5. Instruction of personnel in correct use of radioisotope sources, and the issue to them of radiation monitoring devices when required by the regulations.

6. Notification to the controlling authority of the loss of any radioisotope, or of any incident such as mechanical damage or fire to the radiation gauge.

7. Ensure that radiation warning signs are prominently located and are maintained in a clean, intact and legible state.

Included, as part of the *Vendor Data* provided by Thermo Fisher, are details of the radiation gauges and radioisotopes. This information is to be retained by the site RSO.

Safety and Environmental

This section covers information safety and environmental protection issues, which include Probe Protection Devices, Safety Guards, Radiation Protection and Environmental Protection.

Probe Protection Device

In the event that any operating conditions are abnormal (e.g., power, air supply, probe window rupture, etc.) the MEP pneumatic hoist will automatically raise the probe from the tank so as to prevent possible damage to the probe detector or source. The probe cannot be lowered into the tank until such time as the problem is rectified. The cause of problem (e.g. window rupture) is reported on the display screen of the computer.

In the event that a door is opened or the emergency stop button is pressed, the probe will be locked in its position. In which case the user is responsible to remove the cause for the emergency stop event as safely as possible, so that probe can be raised out of the slurry for its own protection.

Electrical Safety

The Thermo Scientific MSA L Panel Controller has a Mains Isolator switch interlocked with its door. This is provided to prevent injury from electrical shock. Inside the MSA 330 controller all low voltage connections (250V to 110V) on the left side of box below the mains isolator are protected by plastic covers to minimise the risk of electric shock. The uncovered section of the M Panel Controller is only 24V powered control electronics.

Radiation Protection

The MEP containing the radioisotope emits a primary beam of radiation from the probe window in the forward direction. Under normal operation, with the probe lowered into the analysis tank, the tank itself and the slurry therein will shield and absorb this radiation

totally. In the raised position there is potential for some exposure, however this is minimized by:

1. Setting the pointing direction of the probe away from walkways and if necessary restricting access by humans to the area into which the probe is directed whilst raised. This arrangement should be established once and for always by the Thermo Scientific commissioning engineer before the source is actually loaded for the first time.

2. Always attaching the "standard biscuit" to a raised probe as soon as possible after rising. This acts as a very effective shield as well as providing data that confirms or corrects probe accuracy.

3. The internal probe has an automatic internal shielding function. In the event of a window rupture or other abnormal operating condition leading to the hoist being raised, the X-ray source and detector will be retracted above the polymer window to minimise user exposure to radiation. The retraction mechanism has been designed to be "failsafe". If the system is properly installed and cared for the source will be shielded after loss of compressed air and electrical power. The X-ray source and detector is raised into the shielded position by compressed air by a pneumatic cylinder. This is supported by the presence of stored pressure in an air tank (receiver) which will raise even if air is disconnected by customer. Finally, once retracted an internal spring will ensure the retention of the source and detector in the shielded location.

4. In addition a visual status system is employed to indicate shielding status of probe. Two colour lamps are integrated into the top of the AM234 cover. A green one to indicate confirmed shielding and an amber one to indicate potential X-ray emission from lower leg (see Figure 1-1). The four possible states are:

    a. Green lamps on steady: the source is shielded.

    b. No lamps on: the power may be off or a fault condition exists.

    c. Amber lamps on steady: assume X-rays are being emitted from lower Mylar window. If the probe is immersed in slurry, the X-rays will be contained in the tank so operation is still safe.

    d. Amber lamps flashing: The source is in transition, the sensors are not operating correctly or the air pressure is incorrectly applied.

Figure 1-1. Ring of LED lamps indicate when X-rays are ON or OFF

5. If the probe is in transition between shielded and unshielded locations, then the amber lamps will flash alternately. This is a normal and brief condition. If the transition not complete in 10 seconds, then a fault condition is indicated.

6. Fault Behaviour. If amber lamps flash on and off with a 1s ON period, without any green lamps, then a fault has occurred. Approach with caution and verify probe status with by viewing through the polymer window with a mirror. Never look at probe directly. A suitable long handled mirror is provided in the standard toolbox delivered with the equipment.

   In any fault condition, the probe is, by default, driven to the shielded location, but approach with caution until this is confirmed. Three possibilities for this state are:

   i. The sensor behaviour indicates a sensor fault (broken or wrongly positioned sensors). In this situation probe should still be forced to shielded location. This should be confirmed with the mirror.

   ii. The probe has not completed the transition between safe and operating locations within ten seconds. The internal retracting mechanism is jammed or the compressed air pressure is low. Probe position should be confirmed with a mirror before proceeding.

   iii. The probe has been connected incorrectly. The sensors, cables or solenoids may be wired incorrectly or air tubes crossed over. Air tubes are colour coded to minimise the chance of faulty installation.

Note: Being relatively “soft”, X-rays from the MEP-300 are strongly absorbed in air and will not travel significantly more than one metre. This can be seen in Figure 1-2 and Figure 1-3. ▲

Environmental Protection

By its nature most of the mechanical parts of the analyzer system have to operate under the normally arduous environmental conditions that prevail in a mineral processing plant. The design minimizes the number of moving parts thus exposed and specifies large safety margins and wears lifetimes on those that are. Electrical and electronic control equipment is environmentally protected to AS/NZS 60529-2004 class IP66 (NEMA4X). *Materials Specifications* are given in Chapter 3.

Environmental operating conditions are:

- MEP-300 (AM234): Ambient operating temperature: -10 to +55°C. (Air temperature) or 2 to 55° C (slurry in contact with the probe).
- Thermo Scientific MSA L Panel and M Panel Controller: Ambient Operating Temperature: -10 to +55°C without active cooling option, assumes that this is the maximum temperature of the external surface of the cabinet.
- Direct Solar Radiation: direct sunlight falling on the MSA-330 controller or AM234 probe may raise their internal temperature considerably. Where this possibility exists the Customer must install a sun shade over the controller. This shade may also require side panels or curtains to intercept morning and afternoon sun or it may be possible to locate the controller so that it is shaded by existing structures at those times.

Note Thermo Fisher recommends that a roof be installed over the MSA-330 controllers if it is to be installed outdoors or even indoors if significant spillage is expected from above. ▲

Caution The controller's IP rating may be compromised by improperly sealed glands or gland holes. ▲

Radiation Safety

For stability and long term reliability, this analyzer uses a small button radioisotope (a disc of 8 to 15 mm diameter) as a source of X-rays. The part of the analyzer (the probe) that contains the radioisotope is classified as an industrial *Radiation Gauge* by the International Commission for Radiation Protection (ICRP).

Note A "trefoil" radiation warning sign must be attached to each analyzer in the plant. The local radiation regulatory authority can provide details of requirements. ▲

Maximum Allowable Radiation Levels/Doses

The ICRP has set two limits for radiation exposure; one for the general public and one for personnel who work daily with radiation and whose exposure is monitored. These levels have been adopted by many

countries including Australia via the National Health and Medical Research Council (NHMRC). These levels are:

7. 1,000 µSv per year maximum allowable radiation dose for the *General Public.*

8. 20,000 µSv per year maximum allowable radiation dose for Radiation Workers (i.e. in an industrial environment).

The allowed radiation exposure may be received in several short high level bursts or as a low even rate throughout the year, e.g. 1,000 µSv per year is equivalent to 0.5 µSv per hour for 40 hours per week for 50 weeks per year.

Radiation Levels around the Analyzer

Because the probe is used in an industrial environment and classified as a *Radiation Gauge*, the maximum allowed levels of radiation around the analyzer when the probe is in normal operation in the plant (i.e. around the Analysis Tank) is 500 µSv per hour at any point 50 mm from the external surface and 10 µSv per hour at any point 1000 mm from the external surface.

Actual typical radiation levels around a probe in operation in an Analysis Tank are shown in Figure 1-2.

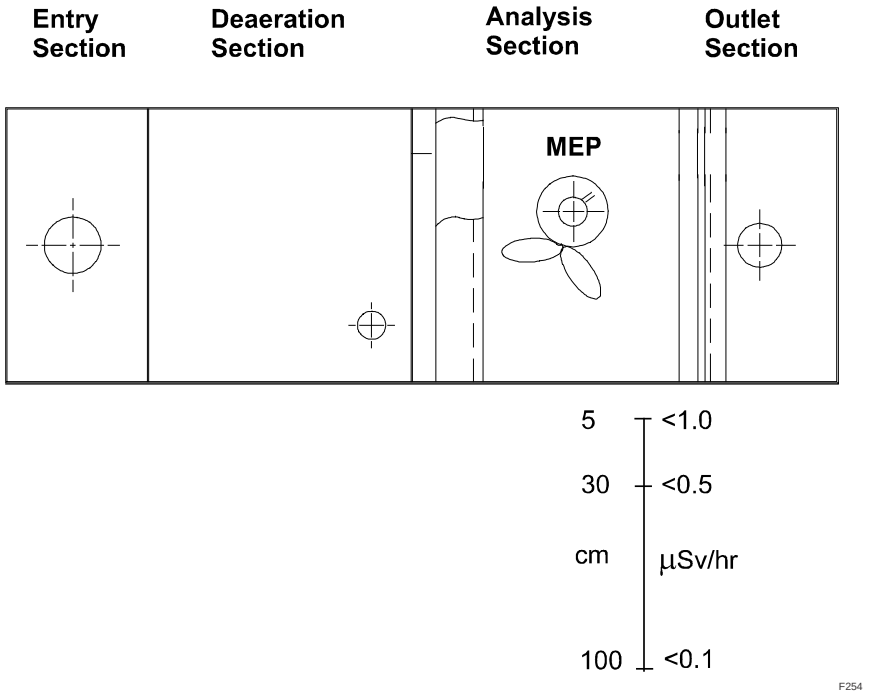


Figure 1-2. Typical Radiation Levels around an Analysis Tank with an MEP in Operation

When the probe is mounted in the operating position (i.e. lowered into the Analysis Tank), the radiation levels around the analyzer are negligible because the most source X-rays only penetrate about 5 mm into the slurry. The most penetrating x-rays from Am^{241} are attenuated by 1000 fold in about 140mm of slurry. But more typical sources are less than one tenth as penetrating. The active window diameter is 34 mm.

When the radioisotope is mounted in the radiation gauge, the radiation levels on the surface of the gauge (probe) are low enough for safe handling in all operations. Typical radiation levels around the probe are shown in Table 1-1, Table 1-2 and Table 1-3.

The probe emits radiation intensely in the forward direction from the gauge head. It is always advisable that radiation levels are kept to a minimum so it is recommended that suitable shields be placed on the probes whenever they are removed for extended periods of time.

Shielding the radiation from the probe can be done by means of attaching the "standard biscuit" (supplied) by clipping it around the window of the probe head.

Caution The beryllium window is very thin and fragile. Take care not to touch it with the screws, tools or anything that might damage it. ▲

Caution Avoid looking directly at the source closer than one metre. Always use a mirror when inspecting the radioisotope source closely. A suitable mirror with a telescopic handle (part number 66564) is included in the tool kit provided by Thermo Fisher. ▲

Figure 1-3. Maximum Radiation Levels around the Probe (MEP) when raised out of the Analysis Tank (automatic shield functional).

Table 1-1. Maximum Radiation Levels 200mCi Pu238

shielding	5 cm	30 cm	100 cm
Source exposed to window			
Front Standard On	1.5	0.3	0
Front No Standard	6000	400	60
Side	0.6	0.15	0
Back	0.5	0	0
Source retracted			
Front	3.5	0.39	0
Side	0.9	0.26	0
Back	0.86	0.17	0
Source loading tool on source holder			
Front	3.2	0.26	1
Back	9	0.4	0.12

Table 1-2. Maximum Radiation Levels 50mCi Cd^{109}

shielding	5 cm	30 cm	100 cm
Source exposed to window			
Front Standard On	4		
Front No Standard	54000	2700	250
Side			
Back			
Source retracted			
Front	50	6	
Side	0.7		
Back	1.6	0.15	
Source loading tool on source holder			
Front	0.4		
Back	50	2.6	

Table 1-3. Maximum Radiation Levels 30mCi Am^{241}

shielding	5 cm	30 cm	100 cm
Source exposed to window			
Front Standard On	4	0.5	
Front No Standard	19000	1000	110
Side	0.73		
Back	0.53	0.15	

shielding	5 cm	30 cm	100 cm
Source retracted			
Front	41	5.5	0.4
Side	1.2	0.2	
Back	0.85	0.15	
Source loading tool on source holder			
Front	2.2	0.4	
Back	50		

Note X-rays from the radioisotope sources used in Thermo Scientific instruments DO NOT make the slurry radioactive. Excitation of the atoms in the sample is an extremely short process, lasting for less than 1 thousandth of a microsecond!

Caution The radiation source remains active even if the analyzer power is off. Ask your RSO (Radiation Safety Officer) or contact Thermo Fisher Scientific if you have any concerns. ▲

General Rules for reducing Radiation Exposure

- Minimize the time spent near a source of radiation;
- Maximize the distance from the source of radiation;
- Use shielding between the source of radiation and yourself.

Note Some applications may require the probe to use two or more individual radiation source capsules. ▲

Lifting the MEP-300

Figure 1-4. MEP-300 probe lifting points

If it becomes necessary to lift the MEP-300 probe, first make sure the lower leg is securely locked in place. Two permanent lifting points exist on the probe baseplate which are identified by the ISO lifting symbol and are to be used whenever lifting as a complete assembly (as shown in figure 1.5). Ensure the four baseplate connection points are unfastened from elevator assembly.

Chapter 2 Overview

This user manual *(IOM)* contains technical information and procedures for operating and maintaining an online analysis system known as the Thermo Scientific MSA-330.

The manual is organized into sections for easy accessibility by the personnel carrying out the work. The sections are designed to be stand-alone manuals for the purposes of installing, operating and maintaining the equipment.

This section provides an introduction to the Thermo Scientific MSA-330. It describes what the equipment looks like, its principle of operation, statutory requirements, training requirements and receiving and storage of the equipment on-site prior to installation.

Chapter 4 “Installation” covers activities associated with installing the equipment such as site preparation, utilities required, trade personnel requirements, mechanical and electrical installation, start-up and testing.

Chapter 6 “Calibration” covers the online calibration procedures for the equipment.

Chapter 7 “Operation” covers the day-to-day use of the equipment, including start-up, shutdown, and routine operational and maintenance checks.

Chapter 8 “Maintenance” covers mechanical, pneumatic and electrical service activities. Disassembly procedures are provided for repair and maintenance.

A separate stand-alone manual is provided for WinISA, the controlling software package that is supplied with the equipment. That manual is also provided electronically in PDF format on the WinISA CD/DVD supplied with the equipment.

Introduction

The Thermo Scientific MSA-330 incorporates an XRF Multi Element Probe (MEP) that provides real-time, continuous analyses of key elements and pulp density for control of mineral processing plants. The MEP in an MSA can measure up to 20 elements as well as pulp density, over several streams, one at a time. The resultant data is presented in graphical and numerical form familiar to plant operators, metallurgists and managers on Thermo Fisher supplied server screens and/or the customer’s in-plant SCADA or process control system.

The MEP is a robust solid-state device that supersedes the earlier liquid nitrogen cooled version that has been in use in mineral processing plants worldwide for many years. The MEP forms the basis of analysis in the family of wet sample on-line and in-stream analyzers.

Rather than multiplex the slurry through a single flow cell measurement zone, the Thermo Scientific MSA works by moving a probe between adjacent slurry streams, bought together in a single location. See Typical Components and Configuration for details.

Typical Components and Configuration

A typical Thermo Scientific MSA is shown in Figure 2-1 and the major parts of it are called out in Figure 2-2 and Figure 2-3. A high level view (block diagram) of the whole system is given in Figure 2-4.

In-plant equipment

Typical *in-plant* equipment includes:

The *MSA Frame* to which the Probe Carriage, Analysis Tanks, Controllers and other associated equipment are attached to form an essentially self-contained in-stream analysis unit providing stream measurement with assay up-date times of typically one minute and a cycle time of about seven minutes for a six stream MSA. The times and sequence can be changed using WinISA. For example if more timely data is required from one or two particular streams, these can be set to be visited more frequently. To aid in maintenance of the MEP the last tank position is sometimes kept empty and is designated as a *service bay*, the spot where the probe will always go for cleaning or maintenance.

The MEP (Multi-Element Probe) is the analysis device. It is supported by the pneumatically operated hoist that traverses the length of the MSA frame. To analyse slurry streams the probe is periodically lowered into each of the tanks in the MSA frame in a predefined sequence. A ring of water jets wash down the probe each time it is extracted from slurry, thus preventing analysis being skewed due to contamination.

Figure 2-1. A Typical 6-Stream MSA

An *Analysis Tank* or *Zone* is a specially designed vessel able to de-aerate and homogenously mix the slurry as it passes the probe, thus presenting a representative slurry sample to it for XRF analysis. The MSA may contain up to twelve small (300 mm) analysis tanks or a smaller number of wider tanks or any combination thereof. Each tank includes a *stirrer/agitator* to mix the slurry and a *water spray* for froth suppression. The water spray for each tank can be independently optimised using the needle valve found on the manifold near the main water inlet of the MSA. A flanged outlet is provided under each tank for maintenance purposes (drain). A cross-cut sampler is fitted to the outlet section of each analysis tank in the MSA frame.

The main advantage of using individual analysis tanks for each stream rather than re-directing flows from different streams into the same analysis tank are:

- Analysis tanks can handle a very large dynamic range of flow rates.
- No need for slurry de-multiplexing.
- No possibility of cross-contamination between streams.
- No emptying, filling nor washing times. The probe is washed during movement between streams.
- Metallurgical Samplers can operate independently of the ISA system, thus allowing shift composite samples to be taken.
- The outlets can easily be re-directed back into the process. It is still possible re-direct a number of process streams to a common sump.

A *Metallurgical Sampler* is located at the outlet of each Analysis Tank. Each sampler, controlled ultimately by the RLC has both manual and two types of automatic modes (shift and calibration mode). These are selectable via the Operator Interface (OI) panel. These samplers are ideal for both calibration purposes and the collection of shift composite samples.

The stainless enclosures along the back of the MSA frame house all the electrical switchgear and control electronics to drive the MSA.

Control switches and buttons needed on a daily basis are found along this side (the back) of the MSA. The Operator interface (OI) panel, which ties intimately into the RLC, controls and monitors probe movement, sampling and various safety aspects of the MSA.

The WinISA Server provides the computational and data logging resources needed to present meaningful information to the customer. One or more servers are involved and they will usually serve more than one MSA and/or other Thermo Scientific analyzers simultaneously.

These servers can send data and alarms to the Customer's process control system over their plant network. Refer Connecting the MSA to the Central Computer in Chapter 4.

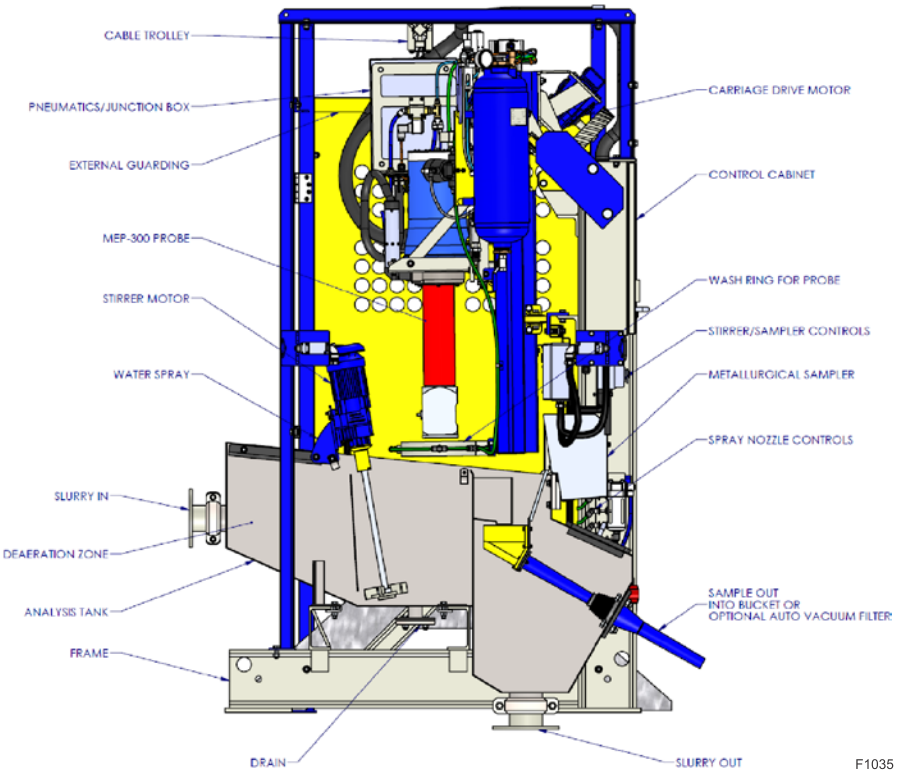


Figure 2-2. The MSA – section view.

Where the flow rates are large, *primary samplers* (such as Thermo Scientific SamStat) may be provided as part of the system or optionally provided by the Customer. Such samplers are required to limit the slurry stream flow rates to the MSA to less than 20m^3/hr (nominally 5 – 10m^3/hr) for the small (300mm wide) tanks and to less than 35m^3/hr for the medium (400mm wide) tanks (nominally 5-20m^3/hr). Other tank sizes are available for even higher rates.

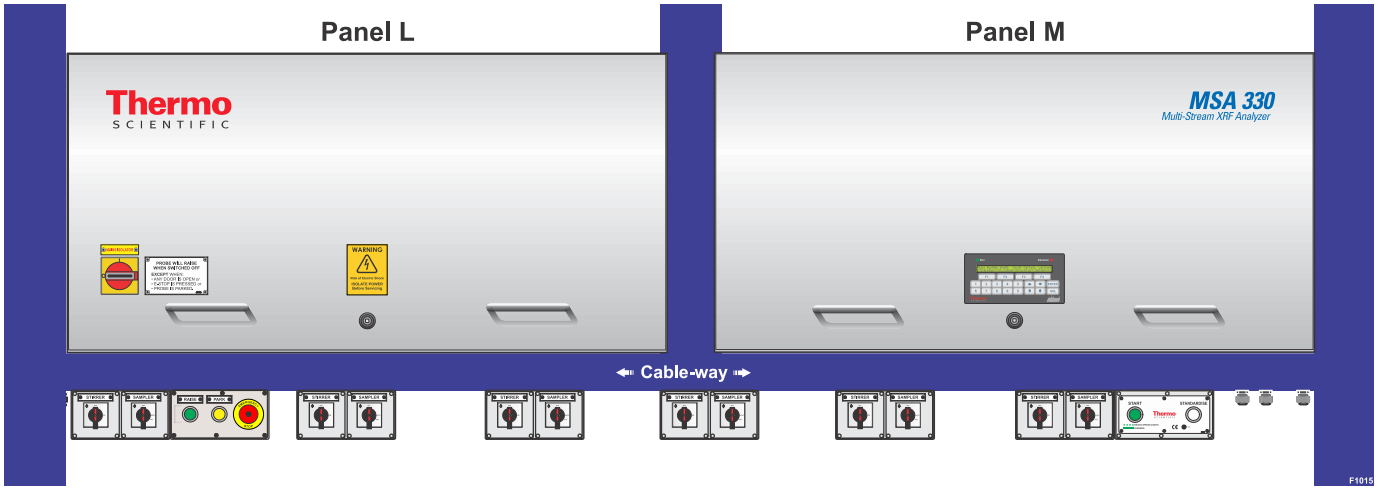


Figure 2-3. MSA Controllers with other controls and isolator switches

Operating Principle

This section describes the basic operating principle of the system. It covers the topics of analysis and slurry sampling.

The Analyzer

The MSA enables a high resolution detector (MEP) to be applied to up to twelve streams. The MEP is mounted on a platform that moves both horizontally and vertically so that it can be lowered into any one of the specially-designed flow-through tanks (known as Analysis Zones or AZs). The purpose of the MSA drive mechanism is to transport the probe between AZs in minimum time. The MSA unit is modular in design so that AZs can be added up to a maximum of twelve. The base MSA module (frame) can house up to six 300 mm wide AZs and when extended can accommodate twelve such tanks.

Independent Metallurgical Samplers are fitted as standard at the outlet of each tank. These samplers are of the high accuracy cross cut type and are a critical part of keeping the MEP calibrated.

Vertical movement of the MEP is achieved with a pneumatic ram (hoist) that moves horizontally with the MEP. This hoist lifts the analysis probe out of the slurry and clear of the analysis tanks. Horizontal movement is by a three-phase motor and VSD. The motor drives a treaded wheel on a track beam that is designed to shed water and dirt to keep running in the worst possible plant conditions. Accurate horizontal positioning is achieved by feedback from the row of proximity sensors along the back. One sensor per analysis tank is provided.

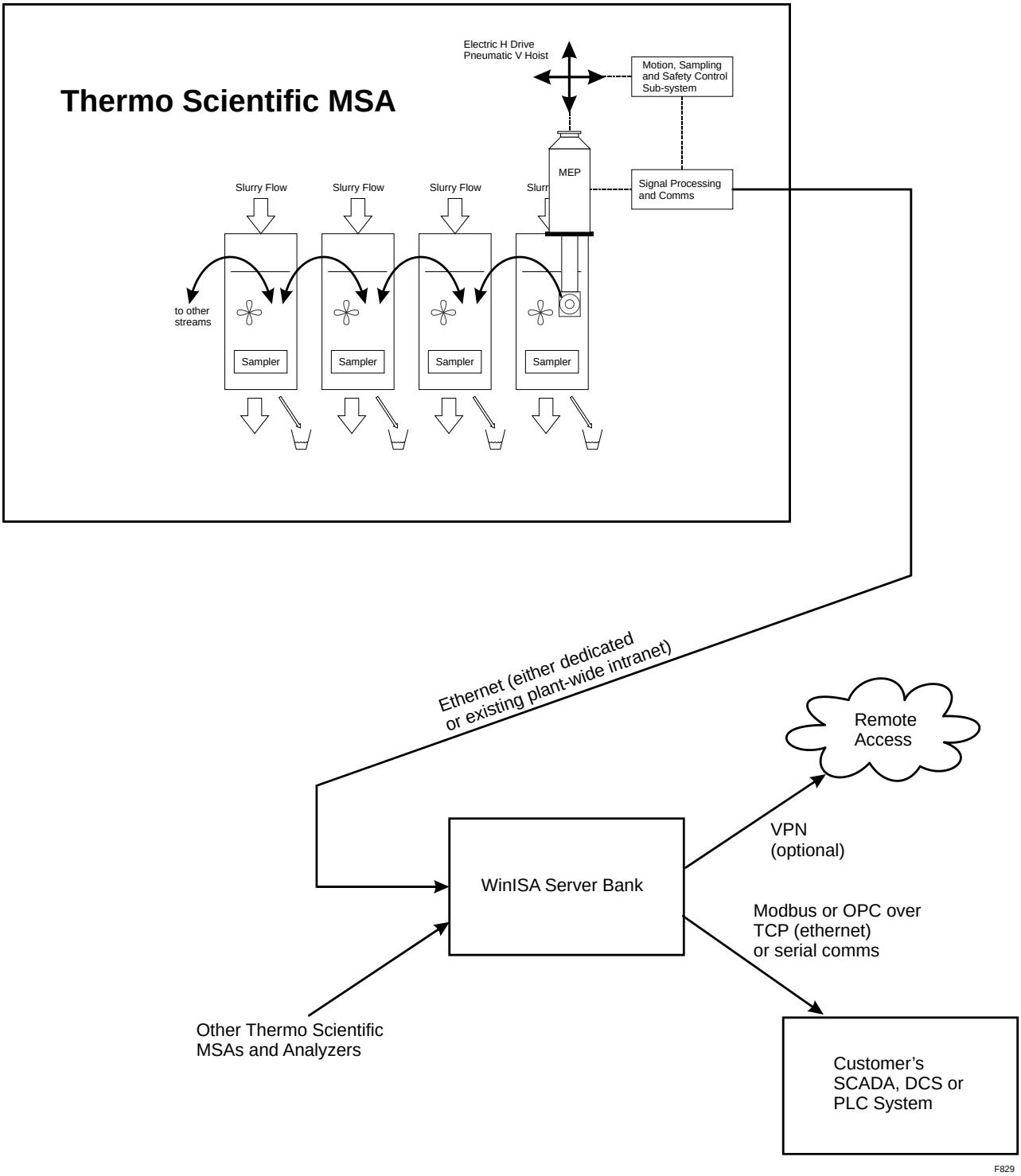


Figure 2-4. The complete MSA system – a block diagram

The probe can also be raised from the slurry and parked to a service zone by pushing the PARK button.

The Remote Logic Controller (RLC) is in Panel M, one of the enclosures mounted on the MSA frame. It controls key functions of the MSA unit (e.g. probe movement, metallurgical sampling and stirrer operation) with user interaction obtainable via the Operator Interface

(OI) panel located on the cabinet outside panel. The stream measurement time, sequence and data analysis is done on the WinISA Server.

One of a bank of WinISA computers, normally located in a control room, will decide when and which stream to select and control the measurement time. In normal operation the computer issues commands to the MSA to move to a particular stream where it will stay until instructed to move to another. Providing the MSA is not under an alarm condition such as *emergency stop*, *parked*, *manual mode* or *guard door(s) open*, it will respond to the command immediately.

Each element in the slurry emits fluorescent X-rays of an energy and intensity which is characteristic of that element and its concentration. The rate of X-rays (X-ray photons of a given energy) is proportional to the concentration of the corresponding element in the slurry.

The MEP is calibrated independently for each element of interest per stream against a suite of samples, taken over a period of time, to cover the expected range of plant operating variables and conditions affecting each stream. This analysis data is sent to the WinISA computer that controls the MSA stream sequencing. That computer also logs the incoming data, computes the assays using calibration equations and displays the assay information in tables and as trend graphs. This information is also made available to the customer's process control system.

Slurry Sampling

The correct presentation of slurry to the analyzer is fundamental to the success of any in-stream analysis system. The MSA is designed to present to the analyzer, a representative sample of the main slurry stream. The Thermo Scientific MSA installation may in some cases involve several stages of sampling so that a statistically correct sample can be obtained to enable accurate measurement. This sampling can also be used to capture shift composite samples.

Statutory Licensing Requirements

For protection of workers and the public, the use of radioisotope sources and radiation gauges is regulated by a responsible government authority. Similar regulations are in use in most countries and they are all based on recommendations of the International Atomic Energy Agency (IAEA).

Note The AM282/30 Multi-Element Probe (MEP) is classified as a Sealed Source *Radiation Gauge* under most regulations. ▲

The onus is on the Customer to notify their local regulatory authority with details of the radiation gauges and radioisotopes to be used in their

XRF analyzer system to ensure compliance. The regulations normally provide for the following matters:

- Registration of ownership of each radioisotope used with the controlling regulatory authority.
- Responsibility of the owner for maintaining records of radioisotope details including locality.
- Responsibility of the owner for safe storage and safe usage of the radioisotope sources.
- Nomination of one person as a Radiation Safety Officer (RSO) to carry out the nominated duties in relation to safe working practices.
- Instruction of personnel in correct use of radioisotope sources, and the issue to them of radiation monitoring devices when required by the regulations.
- Notification to the controlling authority of the loss of any radioisotope, or of any incident such as mechanical damage or fire to the radiation gauge.
- Ensure that radiation warning signs are prominently located and are maintained in a clean, intact and legible state.

As part of the *Vendor Data Supply*, Thermo Fisher Scientific provides details of the radiation gauges and radioisotopes and this information is to be retained by the site RSO.

Training Requirements for Plant Personnel

During site commissioning, your Thermo Fisher Scientific engineer will provide hands-on training in the operation, radiation safety and routine maintenance of the analyzer system. This course will complement the operation and maintenance procedures provided in this manual.

Radiation levels around the MEP are very low; however, it is usually a requirement of the regulatory health authorities that site personnel are licensed to handle radioisotopes and use radiation gauges. One site employee shall also be appointed as the Radiation Safety Officer (RSO). This implies that at least one site person must be formally trained in radiation safety and become suitably licensed. Your local regulatory health authority provides the formal training and licensing, therefore this cannot be done by Thermo Fisher.

Note Any site personnel who are required to remove the probe window and radioisotope source holder may be required to be licensed or supervised by the RSO. Check with your local authority. ▲

Any other operational or maintenance staff who will not required to work with the actual radiation gauge (the MEP itself), do not need to be licensed; however, they must be informed of the radiation safety

issues involved when working near the MEP (e.g. to maintain a stirrer). This education can be done by any Thermo Fisher engineer during commissioning or it can be done by other trained and licensed site personnel.

The soft X-rays from the MEP travel in straight lines and are attenuated effectively by one metre of air. Avoid working in close proximity while the probe is unshielded, but if you have to, make sure it is facing away so that no part of your body is in line of sight of the window.

Never-the-less, it is the responsibility of the site RSO or other licensed and responsible personnel to ensure that the probe is adequately shielded whilst maintenance personnel carry out any work near the MEP. The "standard biscuit" used for standardising the probe also serves as a radiation shield for the probe (see Figure 6-2). It is often convenient to attach the standard during maintenance shut-downs (see Overview (Standardise) in Chapter 6. Even unshielded, the radiation level drops to near background within one metre of the front of the probe.
It is essentially background level behind and side-on to the probe.

Thermo Fisher holds formal training in Australia for its customers on operating and maintaining MSA and other analyzers. Additional training courses can also be held on-site upon request and these are usually from two to five days duration depending on the customer's training requirements and the number of attendees. Refer to Where to find more information.

Receiving and Storage of Equipment

This section describes the procedure to follow for the receiving and storage of the equipment.

Receipt and Inspection

Upon receipt of containers and crates, inspect for any obvious damage during transport. Take detailed notes and photographs of any noticeable damage and notify the Transport Company and Thermo Fisher Scientific immediately.

The equipment received should be checked off against the *Packing List* to ensure that items have not been omitted. Notify Thermo Fisher immediately if you think that something may have been omitted from the consignment or lost en route.

Note Electronic equipment can sustain electrostatic damage without evidence of physical abuse. ▲

Storage Prior to Installation

Any equipment that is not required for initial installation, i.e. equipment which is only required for system testing and calibration by the Thermo Scientific engineer upon arrival on-site, should be left packed in its shipping crates and stored in a dry safe location away from direct sun, corrosive fluids and vibration. For example, the isotope, computer equipment, spare parts, test equipment and consumable items.

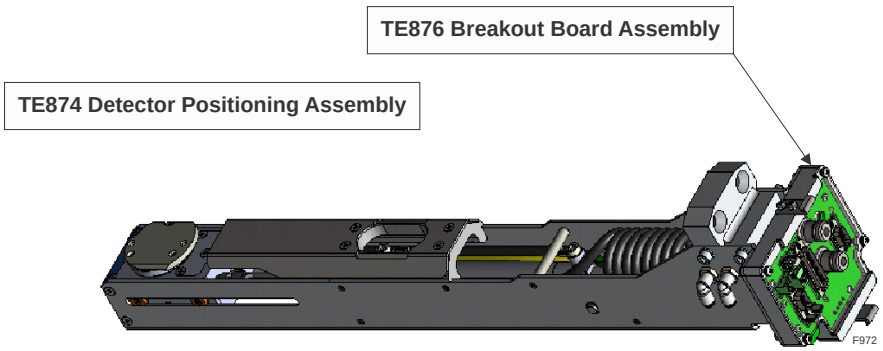


Figure 2-5. Internal parts of the MEP-300 possibly shipped separately

The location of the TE874 Probe Insert Assembly with its Breakout Board as shown in Figure 2-5 and any spare SDD detector(s) as shown in Figure 2-6, needs to be ascertained as soon as delivered and stored in an air conditioned location where temperature does not exceed 25°C. SDDs, including the one embedded in the TE874, may suffer a reduced lifetime if stored at a higher temperature.

Generally the radioisotope should not be stored with the MEP300 probe for long periods as they have different storage requirements which may not be available in one location depending on mine conditions.

- The radioisotope generally needs to be stored in a secure location.
- The MEP300 probe should be stored in a dry cool location.
- If the radioisotope is Am^{241}, Cm^{244} or Pu^{238} then it may slowly damage the detector with which it is stored.

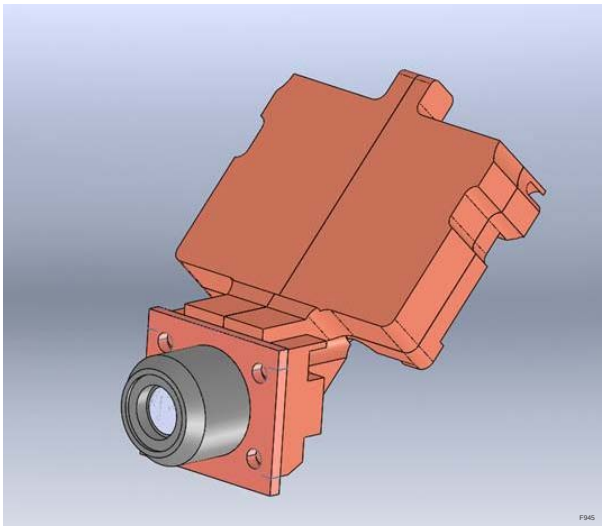


Figure 2-6. The TE877 Silicon Drift Detector (SDD)

Note Any damage to or loss of equipment whilst stored on Customer premises may result in delays in commissioning the system and additional costs to the Customer. ▲

Cleaning and Storage for Extended Plant Shutdown

If the plant is to be shut down for a long period of time then the owners may choose to remove the radioisotope from the MEP for safe storage. This is not a requirement by Thermo Fisher Scientific but is strongly advised in the case that the radioisotope is Am^{241}, Cm^{244} or Pu^{238} .

The inner probe (Figure 2-5) should be stored in a clean air conditioned place for extended plant shutdown to avoid exposure to temperatures above 25°C or contamination, which would reduce detector lifetime

Note Replace the upper shroud and window after removing the detector to ensure the inside of the housing remains clean. ▲

Note If the radioisotope source is to be removed, it must be stored safely and the local radiation authority may require notification of its storage method and location. ▲

The remaining components of the analyzer system, i.e. electronics, computer equipment, etc. should just be shut down with mains power tagged out to all in-plant equipment.

Drain the tanks and wash down the analyzer. In some situations it may be desirable to cover the equipment with tarpaulins or similar and/or take measures to prevent condensation or other water damage. It is recommended that an inventory of the stored equipment be maintained.

Cleaning and Storage for Periodic Plant Shutdown

During normal plant shutdown, the air and power should be left applied to the MSA-330 to enable automatic maintenance of the system. This may require careful attention to shut down procedures.

Important Put all probes in stability mode by pressing the standardise button with a standard biscuit and keep power and air to the unit. Failure to place system in stability mode may lead to premature degradation of MEP300 detectors. ▲

Should it be intended to continue running slurry through the MSA, please ensure the probe is raised. This will avoid damage to the MEP shroud if the window leaks or ruptures.

The analysis tanks may be pumped out or drained. A blanking plate under each tank can be removed for draining. The whole MSA can then be washed down by hand or a hose with very low water pressure.

Chapter 3 Specifications

This section details the standard specification of material used in fabricating the on-line sampling and in-stream analysis equipment. The section also provides other equipment specification information and including analyzer typical accuracies.

Specification of Materials

The following surface materials and coatings are the Thermo Fisher standards used for in-plant equipment. Other materials and coatings may be used if requested.

Wetted Parts

Multi-Element Probes :

Standard: Grade 316 Stainless Steel

Optional: Grade 2RK65 Stainless Steel for high chloride ion concentrations

Linatex or equivalent coating (in the froth region)

Electronic Enclosures

Material: Grade 316 Stainless Steel

Protection: IP66 to AS/NZS 60529-2004

Paint Specification: Nil

Paint Specification

This section covers the paint specification requirement for the system.

Table 3-4. Safety Yellow Paint Specification

Parameter	Specification
Colour	Golden Yellow – Thermo Fisher No. 43331
Used On	All Mild Steel (usually moving parts and guards)
Class of Blast	To AS1627-4 Class 3 (grit blast)
Primer	TYPE – INTERGARD high build epoxy grey (International paint marine coatings) THICKNESS – 100 microns OR (alternative only) TYPE – Epoxy Val Chem Zinc phosphate THICKNESS – 100 microns
Top Coat	TYPE – INTERFINE 629 (M245) (2 pack high gloss anhydride catalyzed acrylic – finish coat) COLOUR – GOLDEN YELLOW TO AS2700 No. Y14 THICKNESS – 100 microns

Safety Yellow Paint Properties

Durable epoxy tank lining for continuous immersion requirements.

Wide chemical resistance to petroleum products, sea water and inert gas.

Resistance to caustic soda and solvents (suitable choice for the "coated tank" of many selective chemical tankers).

Top coat (Interfine 629) provides resistance to weathering in severe industrial environments such as tankage, handrails etc.

Top coat provides outstanding gloss and colour retention in severe environments.

Table 3-5. Equipment Standard Paint Specification

Parameter	Specification
Colour	Thermo Fisher Sapphire Blue
Used On	All exposed Mild Steel
Class of Blast	To AS1627-4 Class 3 (grit blast)
Primer (1st Coat)	TYPE – Epoxy TFH684/THA044 (International paint marine coatings) hb Surface grey THICKNESS – 100 microns OR (alternative only) TYPE – Epoxy Val Chem Zinc phosphate (M290) THICKNESS – 100 microns
Top Coat (2nd Coat)	TYPE – INTERFINE 629 (M245) (2 pack high gloss anhydride catalyzed acrylic – finish coat Part A – T7158, Part B – T7159) COLOUR – White tinted "Sapphire Blue" Taubman THICKNESS – 50 microns per coat (2 coats)

Equipment Standard Paint Properties

Durable epoxy tank lining.

Wide chemical resistance to petroleum products, sea water and inert gas.

Suitable for exposure to intermittent or sustained wet and immersed conditions.

Top coat (Interfine 629) provides resistance to weathering in severe industrial environments such as tankage handrails etc.

Top coat provides outstanding gloss & colour retention in severe environments.

Mechanical Specifications

This section covers mechanical specifications of the system includes the number of streams, power, air, dimensions, weights etc.

Table 3-6. MSA Specifications

Parameter	Specification
Number of Streams	3-12 (intermittent measurement)
Sequence of Stream	Any order or repetition pattern allowed, without time restriction
Measurement Time	Any - resolution to one second
Re-positioning Time	Typically 12 seconds for adjoining zones and 25 seconds between end zones (12 stream version)
Vertical Drive	The probe is raised by a self-oiling pneumatic cylinder 500 mm stroke 100 mm diameter aluminium barrel with stainless steel rod. Thrust 3020 N at 600 kPa. Lowered under gravity by air release. Pneumatic safety latch enclosed in the cylinder prevents lowering on air failure.
Horizontal Drive	TEFC 400 volts 3-phase 0.37 kW motor with 50:1 worm gearbox driving rack and pinion, service factor is 2:3. Speed control by matched VSD.
Guards	Guards are provided all round as standard, including four hinged access doors that are electrically interlocked to freeze all motion when opened..
Noise	<80 dBA at 1m
Proximity Sensors	Turck Inductive
Water	Clean plant water. 300-800 kPa at approximately 4 L per stream per minute, intermittent
Probe wash down	Four self-clearing nozzles solenoid actuated as probe is retracted from slurry. Wash water is collected by the most recent stream analysed. Washing is inhibited during manual indexing of the probe.
Service Position	A service bay, to which the probe will go when the PARK button is depressed. This service position is useful for maintenance work. It can be any one of the analysing positions, with or without a tank.
Controllers	Thermo Scientific TE460/20 and TE461/20
Communication (Data)	10/100 Base-T Ethernet CAT 5/6 to customer's network access point (< 100 m).
Power (In-Plant)	Standard factory selectable 400/460 Volts AC ±10% 3-phase 48-62 Hz ± 2 Hz (three wires plus earth). Other voltages are available on request. Maximum Power Consumption (with standard 250 W stirrer motors) 3-stream MSA: 1.8 kW 6-stream MSA: 2.9 kW 9-stream MSA: 3.8 kW

Parameter	Specification
Air	Instrument quality Air (clean and dry to 0.1 microns with dew point < 2°C). Pressure nominally 700 kPa (87psi) minimum 450 kPa, maximum 1000kPa. Consumption: < 500 slpm (standard litre per minute) at 600 kPa intermittent flow. Secondary air filter built in. The actual air consumption will vary depending on slurry and ambient temperature. Average consumption is related to ambient Air temperature and slurry temperature Air lines from supplying compressor should be able to provide this flow rates specified Unless specifically designed to supply specified maximum pressure at specified flow rate. It is expected that pressure pipes have a **minimum 25mm nominal bore** from the compressor instrument inlet. If long runs are involved then the pipes should have even higher diameters closer to the compressor, to cope with larger flow rates to other equipment. However, it is the user's responsibility to perform necessary engineering calculations.
MEP (Casing)	316 Stainless Steel (optional 2RK65 available for highly corrosive applications) with Linatex on immersion section
"O" Rings	Viton or neoprene
Analysis Tanks	Options available. • 300 mm wide • 400 mm wide • 500 mm wide Other sizes to order.
Coatings	Refer to Specification of Materials.
Enclosure	Electronics: 316 Stainless Steel. Protection IP65
Stirrers	Thermo Fisher supplied 3-phase 0.25 kW (standard) or 0.75 kW Helical Gear, with impeller to suit 400 mm or larger size tanks. All The stirrers have individual lockable isolators. Other stirrers may be specified depending on the tank size.
Dimensions	Refer to equipment drawings for dimensions in Appendix D of this manual.
Weights	MEP complete (excluding hoist): 35 kg MSA static weight varies depending on size of the unit. Refer to drawings in Appendix D of this manual.

Metallurgical Sampler Specifications

Table 3-7 lists the specifications of AM643/12-260 Metallurgical Sampler that has been supplied with the MSA. This sampler is the Environmentally Hardened (EH) version as described under Description of the Sampler Head in Appendix C.

Table 3-7. Metallurgical Sampler Specification

Parameter	Specification
Type	Linear horizontal cutter
Operation Modes	Manual, Calibration or Local Automatic (Shift) modes of operation, selectable from a switch on the front panel of the controller.
Isolator	Individual isolator on sampler. Isolator switch also initiates manual operation.
Drive	Electric.
Motor	90W DC with integrated reduction drive.
Stroke	300 millimetres.
Cutter	Type B horizontal fixed opening, 10mm wide, 250mm long, and 250mm deep. Wear resistant polyurethane, 95 Duro.
Speed	330mm/sec. Acceleration and dynamic deceleration take place over approximately 10mm at each end of stroke whilst the cutter is out of the stream.
Power	DC voltage, 110 to 180 volts, bipolar, as delivered by the controller.
Stalling Force	150 Newtons (motor protected by controller).
Weight	30 kg
IP Rating	IP56

Analyzer Accuracy Data

Measurement Accuracies of the analyzer system are given in terms of the ***Relative Error*** (error in chemical laboratory assays are also given in terms of this error but usually at two standard deviations (2 s.d.) or 95% confidence, whereas the analyzer is at one (1 s.d.).

$$Relative\ Error\,(\%) = \frac{RMS\ Deviation}{Mean\ Assay}\ x\ 100$$

RMS Error (error at 1s.d, also known as the RMS Deviation) is the

$$RMS\ Error\ = \left[\sum_{i=1}^{N} \frac{(\ x_i - y_i\ )^2}{N-1} \right]^{\frac{1}{2}}$$

absolute difference between the analyzer assay measurement and the accepted “true” laboratory assay for a suite of samples.

The RMS Error includes *error contributions* from:

- Sampling
- Sample Preparation
- Laboratory Assaying
- Statistical (counting) Error
- Instrumentation Error

The Customer must ensure that all care is taken so as that these errors are insignificant so that the RMS Error truly represents the accuracy of the in-stream analyzer.

It is therefore recommended that the chemical laboratory assays have an *accuracy* of better than one third (1/3rd) of the expected analyzer accuracy. Refer Table 3-8.

Table 3-8. Typical Analysis Accuracies

Assy Range	Typical Accuracy (Rel Err) Of Analyzer (%)
Elements in Slurries (%metal):	
0.01 – 0.05	5-25
0.05 – 0.2	4 – 6
0.2 – 1.0	3 – 5
1.0 – 10.0	2 – 4
10.0 – 60.0	1 – 2
Elements in Solution (metal):	
Above 10 g/L	1 – 2
1 -10 g/L	2 – 4
1 mg/L – 1 g/L	3 – 6

With any XRF analysis, the ***accuracy*** depends on:

- Particle size distribution
- mineralogy
- matrix variations of an ore type

The *Precision* of the analyzer is defined as the degree of agreement between replicate measurements of the same sample. The Precision is the same as *Repeatability*.

The Precision depends on the variation in the count-rates due to the random nature of the X-ray emissions. For sealed radioisotope sources,

the X-ray emission is very stable. Additionally the counting statistics are monitored and reported as the Statistical Error. So that Precision is NOT a limiting factor in the overall accuracy of the analyzer, the calibration equations used typically have a Statistical Error of less than one half the RMS Error (at 1s.d.).

Detection Limit is the minimum concentration that can be distinguished from the background measurement. Because background measurements are low with the "clean" radioisotope X-ray source used in the analyzer system, the detection limit is typically much lower than the concentration to be measured and hence is not a limiting factor in the overall accuracy of the analyzer.

Detection Limit (at 95% confidence) is twice the standard deviation of the average background measurement.

Chapter 4 Installation

This section is written for those personnel carrying out the installation of the equipment in the Customer's plant. It is intended to be used by the Customer's trades people and engineering contractors and is written on the assumption that the work will be carried out *without* the presence of a Thermo Fisher engineer. For some contracts a Thermo Fisher engineer may be required to be present to supervise some or all of the installation phase.

An Appendix D to the end of this manual contains the *Foundation and Installation Drawings and Diagrams*. The *Parts Manual* also contains detailed drawings and parts information that may compliment the installation process. It also contains the *Equipment List*.

Resources and Services to be provided by the Customer

It is the responsibility of the customer to provide the following resources during the installation of the on-line sampling and analysis system unless otherwise specified in the contract.

Trades people

- *Fitters* and *welders* to carry out plant modifications such as pipe work, flooring, platforms, etc. in order to accommodate the analysis equipment.
- *Fitters* to carry out the physical installation of the sampling and analysis system metal ware (MSA frame, tanks, pipe work to/from the tanks, probe carriage, etc.).
- *Electricians* to carry out power wiring and terminations.
- *Instrument Technicians* to install data communications cabling, air and water supplies and other terminations.

Project Responsible Officer

The Customer should allocate a person responsible for the overall project and the installation of the equipment. This person is to report back to Thermo Fisher for clarifications and complete and return the *Installation Checklist.*

Note The Customer shall complete the Installation Checklist and return it to the relevant Thermo Fisher Project Manager, before an engineer is sent to site to carry out commissioning and calibration. ▲

Additional services required to be provided by the Customer if a Thermo Fisher engineer is required to be on site to supervise the installation includes:

Messing & Transport

Provide suitable accommodation, meals and local transport for the Company engineers while they are on-site to supervise the equipment installation. Where appropriate, a hire car should be provided.

Communications

Provide telephone/facsimile/email service to Adelaide, South Australia, from the installation site.

Safety Induction

Provide site-specific safety induction training for Thermo Fisher Scientific engineers carrying out site work.

Safety Equipment

Supply any additional site-specific safety equipment or clothing required as part of standard site safety procedures. Thermo Fisher will supply Australian Standard safety helmets, glasses, clothing and boots for their engineers.

Special Tools Required for Installation

No special tools are required to install the MSA. All tooling requirements are standard international metric size.

Customer Scope of Work

Some contracts require the customer to fabricate their own sampling equipment. It is the responsibility of the Customer to ensure that their scope of work for the project is completed in time to carry out the physical installation. A detailed checklist will be provided and should be checked and signed off by the customer, then sent to Thermo Fisher Scientific prior to any Thermo Scientific engineer travelling to site. Other work to be completed by the Customer may include:

Pipe Work & Sampling Equipment

Provide all slurry piping from the process to the AnStat inlet flange and from the outlet(s) back to the process streams. Upstream sampling equipment is to be installed by the Customer where required to optimize stream flow-rates. Thermo Fisher Scientific can provide a range of primary sampling equipment, including the Thermo Scientific *SamStat* for metallurgical accounting quality sampling, or pressure pipe and gravity process samplers, see Appendix E. Thermo Fisher Scientific can also assist with design of sample delivery and return systems. Contact us before commencing installation works (see Service & Warranty).

Access

Provide adequate space around the MSA for maintenance access. Typically at least one metre should be allowed on all sides. Drawings provided in Appendix D indicate access space required.

Solar Shield/ Cover over MSA

It is recommended that a sun-roof be installed over the Thermo Scientific MSA if it is to be installed outside or under slurry tanks that may overflow.

If practical, especially in hot climates, the Controller enclosure should be positioned indoors or under the sun-roof and oriented such the hours that sunlight is falling on the controller is minimized.

Lighting

Provide adequate lighting around the analyzer and electronics. When placing lights be aware that the electronics enclosure door opens to the top and that operators will be required to routinely view the slurry flowing through the analysis tanks. Lightning around the service area is also important.

Maintenance Drain

A blanked, flanged outlet is provided at the bottom of each analysis tank. A tank can be drained by removing its blanking plate. Alternatively the Customer may install a valve on some or all tanks so they can be more easily drained for maintenance.

Slurry Pipe Connection

Each tank is fitted with flanged slurry inlets and outlets to which the Customer connects plant slurry lines. Refer Appendix D for details on flange location and sizes.

Power Supplies

Provide power supplies for in-plant and central control equipment Refer Chapter 3 and Electrical Feed section in this chapter for detail. Specific power details are in Table B-1 of Appendix A of this manual.

Instrument Air

Provide instrument quality air for pneumatically operated MEP hoist and MEP 300 probe. See Chapter 3 for detail.

Data Cables

Provide and run CAT5e/6 twisted pair cable to a suitable network connection point or directly to the Thermo Scientific WinISA computer if it is less than 100 metre in cable length. How the customer integrates the MSA and WinISA into a pre-existing LAN is left to the customer to plan. Thermo Fisher requires only that the MSA is assigned a fixed IP address that can be routed to the WinISA. Refer Connecting the MSA to the Central Computer section in this chapter for further details.

Chapter 5 Installation

This section is written for those personnel carrying out the installation of the equipment in the Customer's plant. It is intended to be used by the Customer's trades people and engineering contractors and is written on the assumption that the work will be carried out *without* the presence of a Thermo Scientific engineer. For some contracts a Thermo Scientific engineer may be required to be present to check some or all of the installation phase.

An Appendix D towards the end of this manual contains the *Installation Drawings*.

Locate Mechanical Assembly

The MSA is often shipped in a partially knocked down state to allow for it to fit in a standard sea freight container. The sections, MEP hoist etc. must be assembled on site. Parts are labelled to allow easy re-assembly. This can be done by the customer prior to commissioning or under supervision of a Thermo Fisher engineer during installation.

Computer Room

A clean, relatively dust free, office type environment is required for the central control equipment (computer, peripherals etc.). The operating temperature should be in the range of 15-32°C and the operating relative humidity should be in the range of 20-80% non-condensing.

Identify the Key Parts

The MSA will arrive on site partly disassembled for packing in crates suitable for air freight. To reassemble it mechanically, proceed as follows.

Caution Do not lift the MSA by its frame, instead fit the special "lifting lugs" provided for each frame end (refer to MSA installation drawings in Appendix D , Figure 5-2 and engineering note 5 for lifting guidelines). Once the frame(s) are in place remove the lifting lugs and fit an end plate to each end of the MSA. Only two end plates are fitted, one at each extremity. ▲

Location and Mounting Up

The stirrers are used to mix the slurry and are mounted on the tanks. The samplers are driven by a DC motors forming part of the drive mechanism. The MEP seats on a pneumatically controlled Hoist. The Hoist is fitted with sensors which indicate its position.

A Thermo Scientific MSA can be installed on any level of the plant. There are many factors to be taken into account in choosing the best location. Thermo Scientific Product Specialists are available to help

plan the best sampling, piping and pumping layout for your plant. Some typical MSA installations are shown in Appendix D.

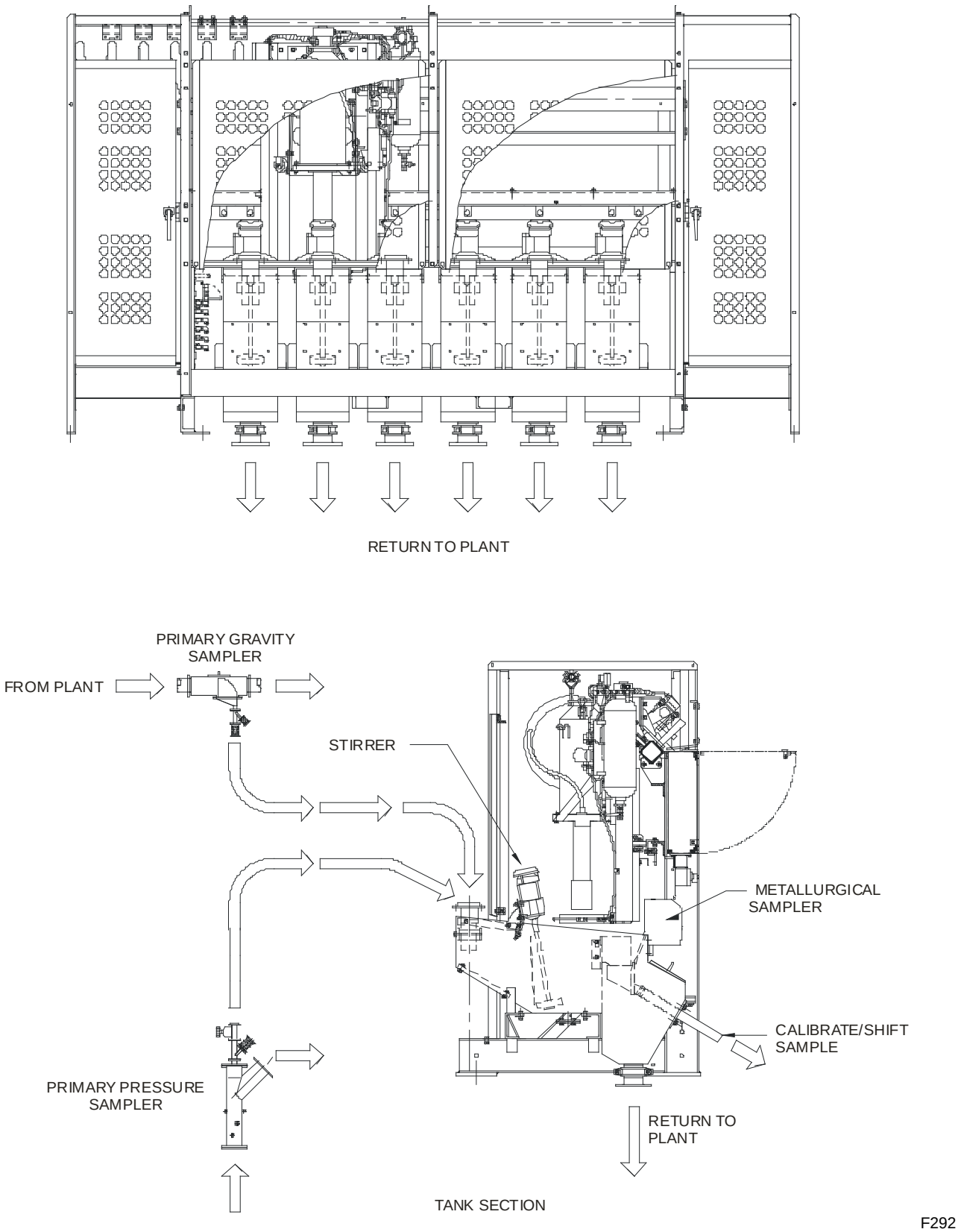


Figure 5-1. Slurry pathways to and through an MSA

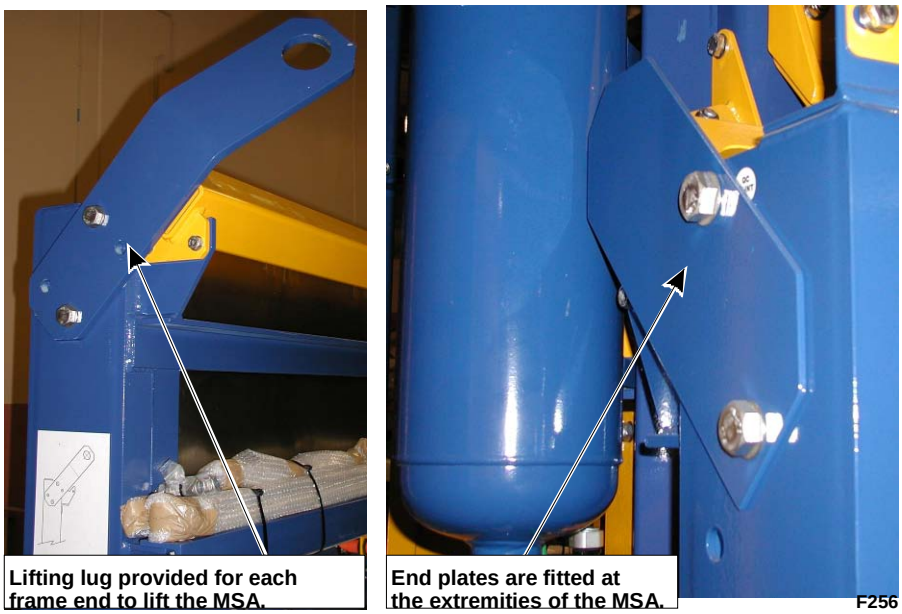


Figure 5-2. Lifting lugs are replaced by end plates

The MSA unit is delivered with the electronic enclosures already mounted. Depending on shipping requirements, the analysis tanks may not be factory mounted and so these will require bolting onto the frame as per your installation drawings. Refer Appendix D.

The stirrers, samplers and hoist are pre-wired at the factory. The so-called Umbilical Cable is quite special and is split into two cables (1.0 and 13 metres long). Do not attempt to extend these cables. They are adequate for the largest MSA.

Caution When arc welding near the analyzer, ensure that good practice is used to prevent damage to electronic components. ▲

Wiring up the System

Once you have everything mechanically installed, the steps you should take to successfully connect and commission MSA are as follows.

Electrical Feed

The first step is to ensure that a three phase power feed is run to the MSA. This must be three wires up to 6 mm^2 and a protective earth (PE) conductor or as required by local authorities or mine wiring standards. Protect this cable against overcurrent with a suitable fuse or circuit breaker at the supply end.

The MSA is built to order and will operate on three-phase power of voltage and frequency indicated at time of ordering. Check the rating plate inside left of panel L to ensure it is correct for your site. Contact Thermo Fisher Scientific Customer Support if it is incorrect. See Where to find more information.

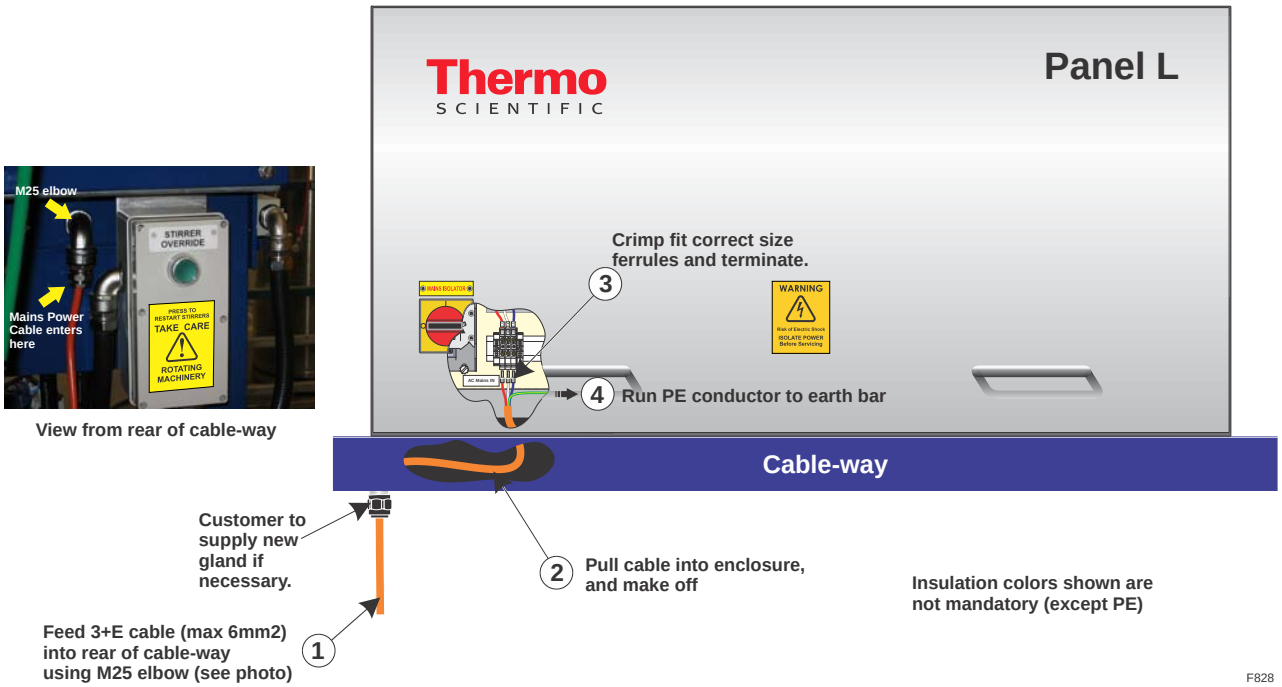


Figure 5-3. Connecting the mains power.

Terminate the power conductors on the terminals marked L1, L2, L3 at bottom left of panel L as shown in Figure 5-3. Clamp the incoming PE conductor under two screws in any empty tunnel on the brass earth bar. Glanding, stripping and dressing of wiring should be done to local standards. Take particular care with fine stranded conductors to ensure that all strands are properly retained and clamped under two terminal screws. Use of a crimp or "boot-lace" ferrule is highly recommended.

Warning Electronic equipment is susceptible to damage by static electrical charge. Handle components with care. ▲

Check the ground circuit is correct according to local standards.

Installing the Probe Carriage

After mounting the tanks, the probe carriage needs to be mounted on the guide rail. See Figure 5-4. The probe carriage is heavy (around 200 kg without shroud or probe) and should be slung and lifted with a crane or other mechanical aid.

Caution Take care not to damage cabling at the top of the carriage when slinging. ▲

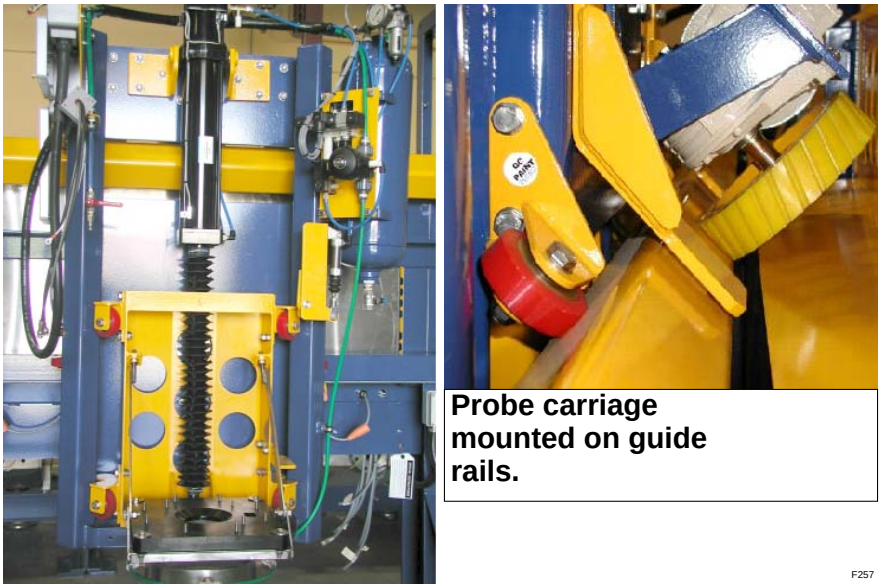


Figure 5-4. Probe Carriage mounted on Guide Rails

The MEP upper shroud) and lower shroud are packed separately for shipping and so require mounting in the probe carriage. Refer section Installing the MEP in the Hoist later in this chapter. The black anaconda probe cable will already be connected at the base-plate; however, the other end of the cable must be terminated in the cable termination/pneumatics box on the probe carriage. The connectors will not be able to be joined at this stage if the umbilical cable has not yet been installed. Refer Installing the Umbilical Cable.

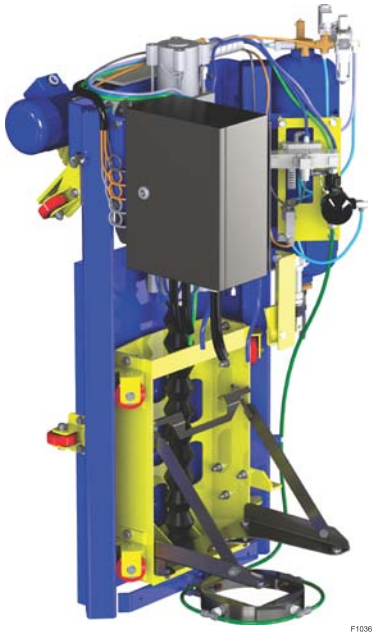


Figure 5-5. MSA Probe Carriage Assembly

Installing the Umbilical Cable

The coiled umbilical cable that connects the probe and other moving items to the rest of the MSA is shown in Figure 5-6. It carries power, signal and control cables as well as the air and water lines to the valves located on the probe carriage.

If not already assembled, connect the overhead gantries and attach the diamond cable trolley rail. Five cable trolley wheels are slotted onto the diamond rail (refer to the installtion drawings in Appendix D). These trolley wheels support the umbilical cable.

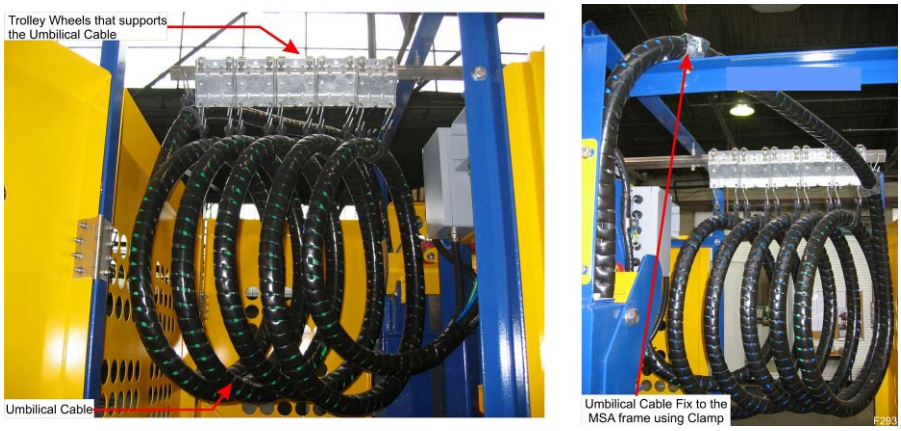


Figure 5-6. An MSA Umbilical Cable

The umbilical is normally shipped attached at the controller enclosure, then coiled up in the first tank. It requires careful mounting on the cable track using the trolleys provided. See Figure 5-6. Loop the cable onto the trolley wheels so that you have five even sized loops.

Take Care Do not unravel the Umbilical Cable. Loop it carefully onto the cable trolley wheels so that if falls naturally into loops already trained into the cable. ▲

Fix the cable to the MSA frame and the end of the trolley rail at the tank #1 end of the frame as shown in Figure 5-6.

In line with good EMC practice, the motor cable runs directly from the Variable Speed Drive (VSD) in enclosure L to the motor without passing through any intervening terminals or junction boxes. This VSD grade cable has a heavy copper screen which is grounded at both the VSD and the motor. Figure 5-7 shows how to re-connect the cable at the motor. Note the wire colors shown in the photo are R-W-B. In practice you may find other colors used. Table 5-1 lists the correct order for all known color combinations. Note that the star point is not connected elsewhere. There is no neutral conductor.

Table 5-1. Wire colors used for carriage motor

Standard	U1	V1	W1
Europe	BN	BK	GY
Australia	RE	WH	BU
US/Can	RE	BK	BU
Unknown	BN	BK	BU

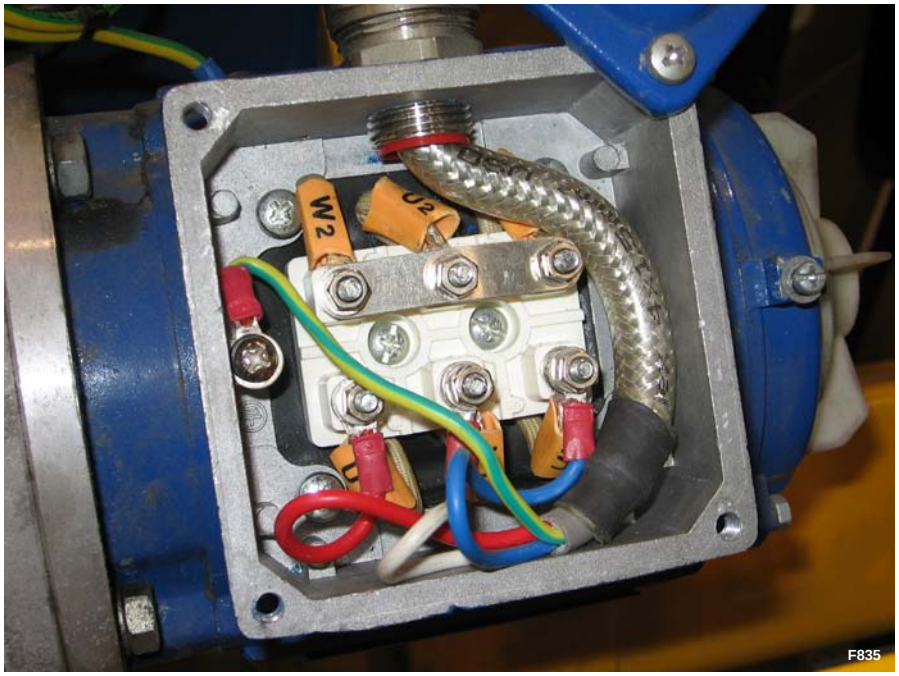


Figure 5-7. Re-connecting the carriage motor

Note Incorrect wiring of the phases may prevent the carriage from moving, or may result in it running in the wrong direction. This will not cause damage however the Position Test will fail. ▲

At the motor drive assembly end clamp the cable into the half-saddle (supplied) on the carriage. (Refer Figure 5-8). Position the cable in the saddle so it clamps on the heat shrink protecting the conduit.

Figure 5-8. Attaching the motor conduit to the carriage

Attach the remaining conduit (the one with rectangular plate) to the left hand underside of the horizontally mounted box using the gasket supplied.

The signal cables for movement, probe cable, air (blue tubing) and water (green tubing) are terminated in the right hand side vertically mounted pneumatic box. All power/signal cables and Probe Signal Cable inside the pneumatic box are labelled.

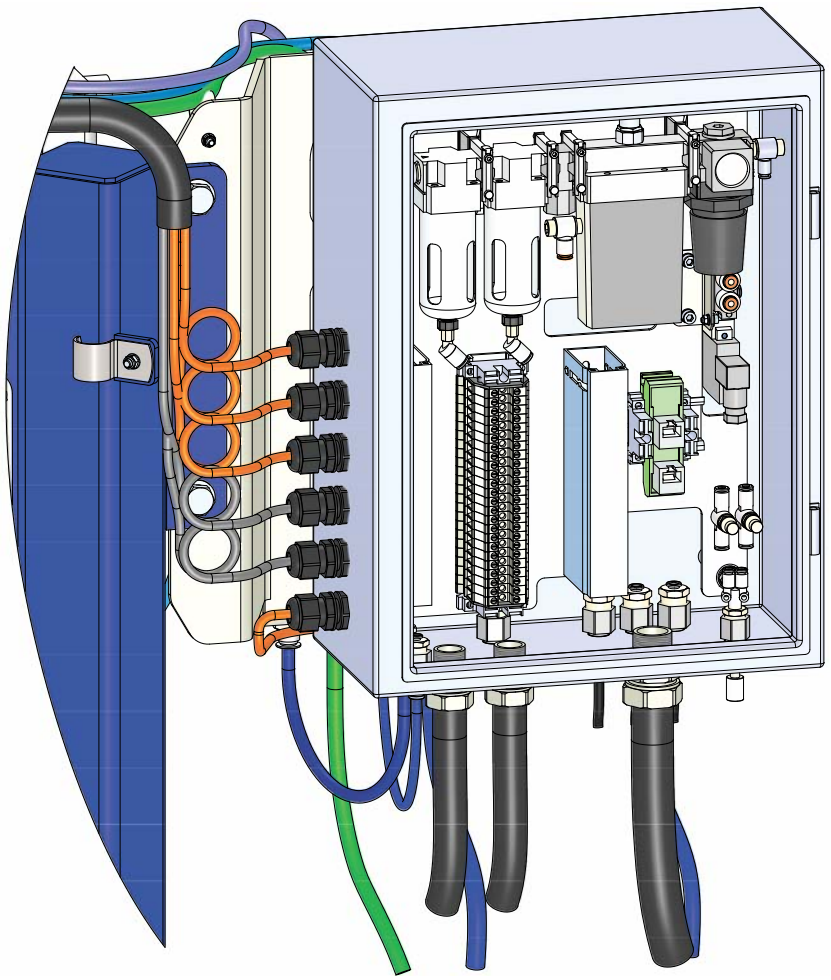


Figure 5-9. Inside of the MSA-330 pneumatic box

Pneumatics

Two pneumatic air cylinders are employed in a Thermo Scientific MSA. One is vertically mounted on the probe carriage hoist and is responsible for lifting and lowering the MEP, see Figure 5-10. A second, much smaller, cylinder operates a safety latch to prevent the probe dropping in the event of compressed air failure. Both of these cylinders operate under automatic control; however they are entirely inside the guarded perimeter of the MSA, eliminating any chance of injury to operators.

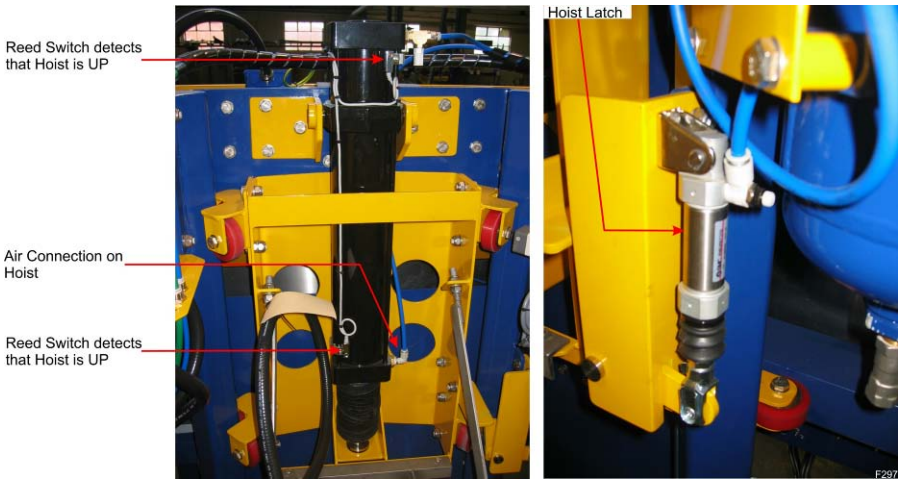


Figure 5-10. Air cylinders used in the MSA

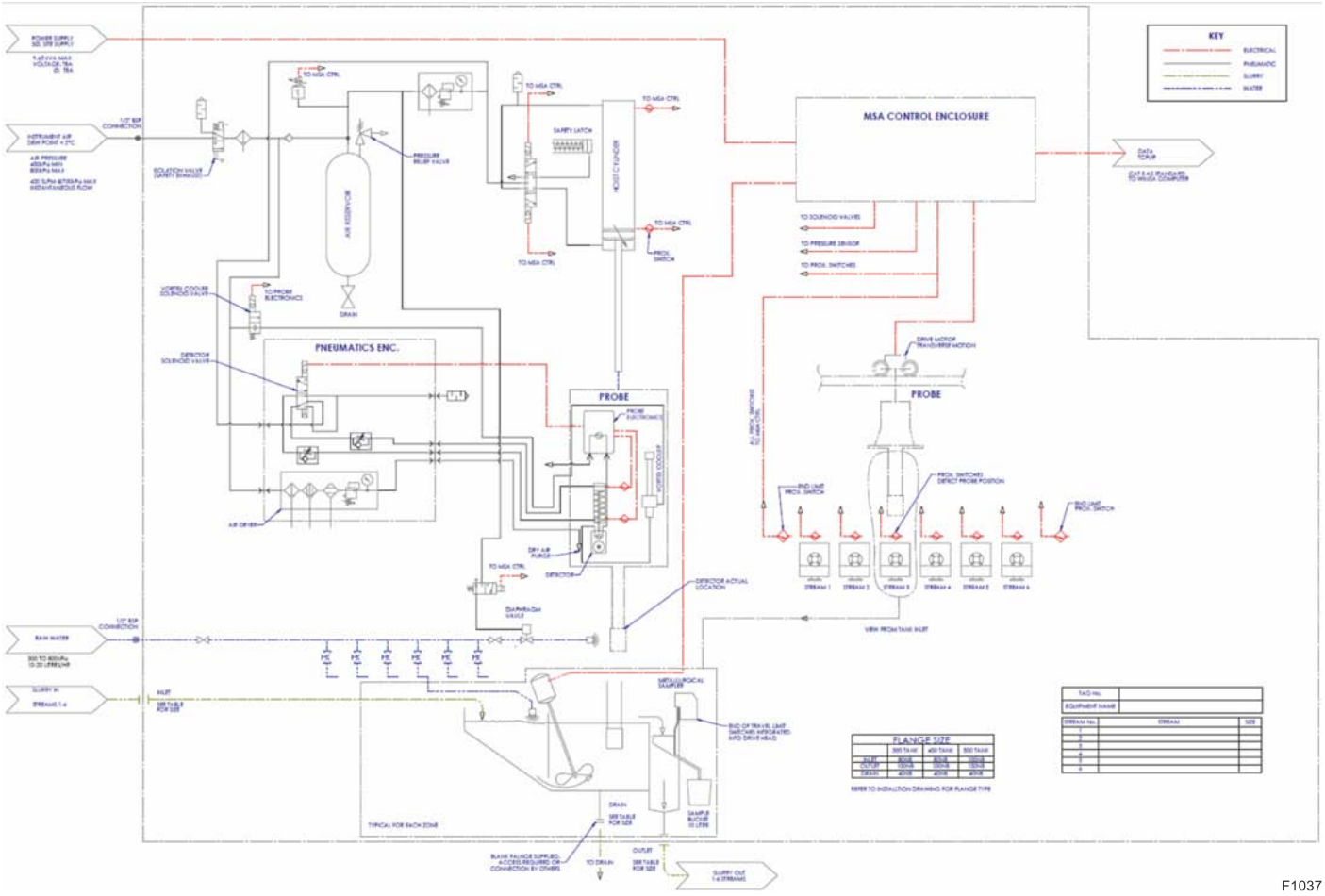


Figure 5-11. P&ID for a typical 6-stream MSA-330

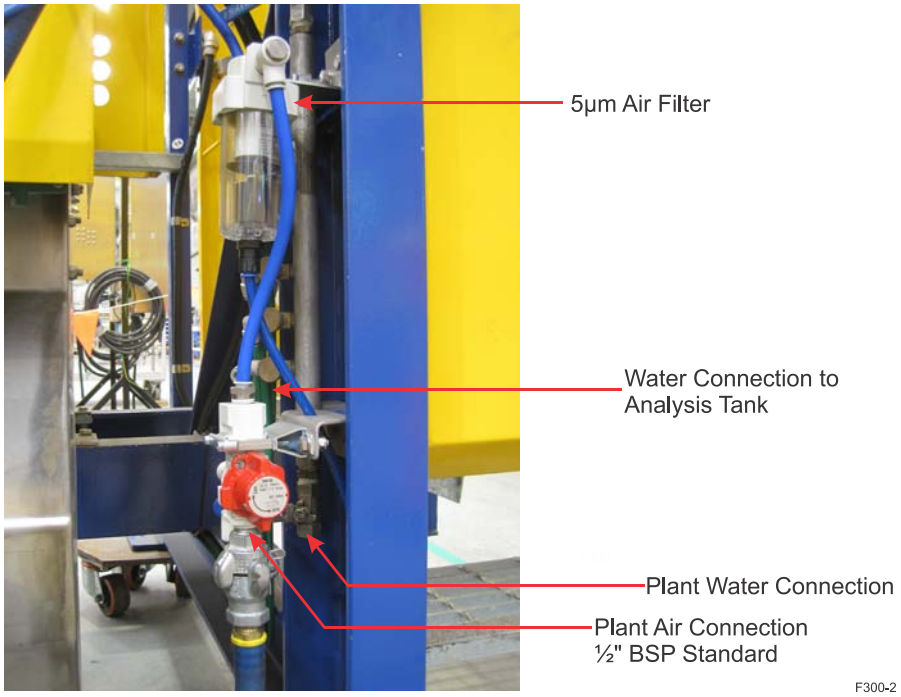


Figure 5-12. Air and Water Connections to MSA from Plant

Air Requirement

Instrument quality compressed air is required at all times by the MEP hoist and MEP-300 probe. Because the probe hoist acts as a safety device to protect the probe in the event of window rupture, air pressure loss or power failure, a reserve air supply receiver is incorporated into the hoist design.

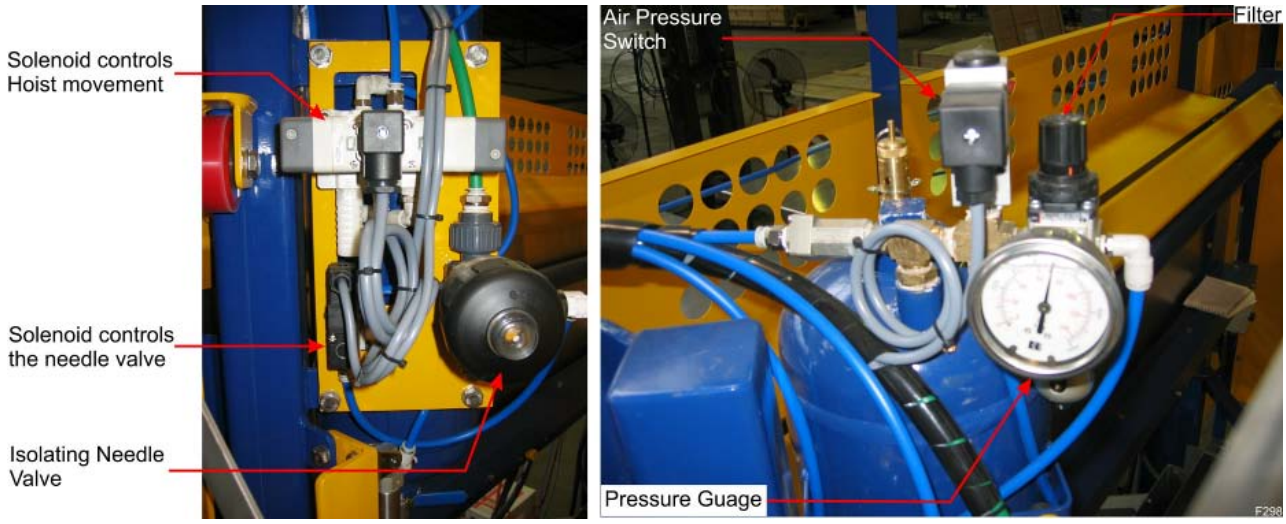


Figure 5-13. Air and Water Assembly used in an MSA

Note In the event of failure of the air supply to the hoist, the probe will be raised from the slurry. Failure is deemed to have occurred if the air pressure drops below about 500 kPa, as detected by the pressure switch mounted above the air receiver. ▲

Note The MSA will cease operation if an air failure or pressure drops to < 500 kPa occurs. An “AirFl” message will be displayed on the Operator Panel (OI). ▲

Air Connection

The hoist air system and air connection points are shown in Figure 5-11 and Figure 5-12 respectively. Figure 5-12 shows the ½” air connection point at the isolation valve.

Note The customer will need to provide the external airline and fittings to connect to the ½” female BSP thread. ▲

Air Isolation

Isolation is via a red handled pressure relief valve located at the air connection point. Switching this valve off will relieve pressure built up in the airlines up until the air reservoir. The check valve at the reservoir will keep the reservoir and all its fed lines pressurised

Water Requirement

A clean water supply is required for washing the probe and suppressing froth. One water spray and water pressure switch is supplied in each MSA. A spray ring surrounds the probe and sprays wash water on the probe as it is raised from the analysis tank.

Figure 5-14. Water Spray per Analysis Tank and for Probe Washing

Note Plant water which contains solid particles or dissolved salts may block the water sprays. It is particularly important to ensure the probe wash down operates every time the probe lifts otherwise bad measurements may result. ▲

Water Pressure

300 to 800 kPa

Water Consumption

10 to 20 litres per hour

Water Isolation

Each supply to the analysis tanks and the probe washing solenoid has an isolating needle valve control. These are located at the water connection point.

Water Connection

Plumb the plant water feed to the water manifold on the MSA frame using a ½ inch BSP fitting. Refer Figure 5-12.

Note Visual inspection is required occasionally to ensure proper water spray operation. Refer Preventive Maintenance Schedule in Chapter 8. ▲

Installing the MEP in the Hoist

The MEP upper cover and lower (leg) shroud will have been shipped together, but require mounting in the MEP hoist frame. The black 1m Anaconda probe cable and the 12mm polyethylene tubing used for delivering air to the vortex cooler will be pre-terminated at the base-plate. Both of these will need to be terminated to the carriage pneumatics box once the probe and carriage are in place.
Refer Figure 5–17 for connection points on the carriage pneumatic enclosure

Figure 5-15 shows the dimensions and weight of Multi Element Probe (MEP-300). Take care when handling it.

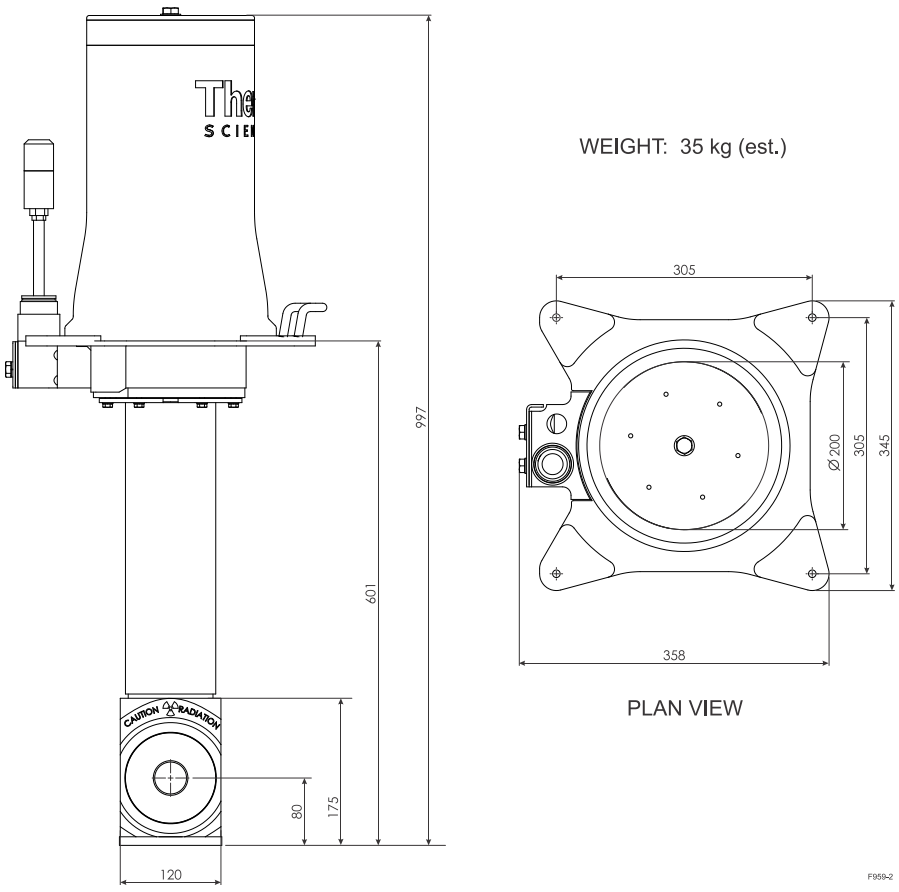


Figure 5-15. Dimensions and Weight of an MEP

1. If not already installed in the hoist frame, the Probe protective shell with black anaconda probe cable is to be set in the frame and bolted into place with four stainless steel isolation mounts with M8 stainless steel studs and nyloc nuts).

2. If not already attached to the base plate, the lower shroud is to be bolted to the underside of the base plate using the six retaining bolts and two curved plates. The probe must be mounted so that its window is facing towards the hoist pneumatically actuated ram.

Note The probe cable assembly is supplied by Thermo Fisher and consists of flexible Anaconda type conduit enclosing the earth conductor, 24 Vdc power, and control and communication conductors. ▲

Note The MEP includes the stainless steel outside casing (lower shroud), the detector and the upper shroud. ▲

The procedure for installing the probe is as follows:

Table 5-2. Installing the Probe

Step	Action
1	Mount the probe base plate to the stainless steel probe elevator bracket in the correct orientation ensuring the probe window is facing the controller side of the MSA. Ensure the four stainless steel M8 vibration isolators are used to couple the probe to the bracket.
2	Check that the probe cable is securely attached to the probe termination block as shown in the Figure Figure 5-16 below. The loose end of the probe cable will require termination to the carriage pneumatics enclosure on site due to the split shipping method. This cable conduit can be seen terminated to the enclosure in Figure 5–17.
5	The last step is to install the detector positioning assembly into the probe lower shroud. This step should be left for the commissioning phase and should only be carried out by a Thermo Fisher Scientific FSE. These steps are outlined below for reference.

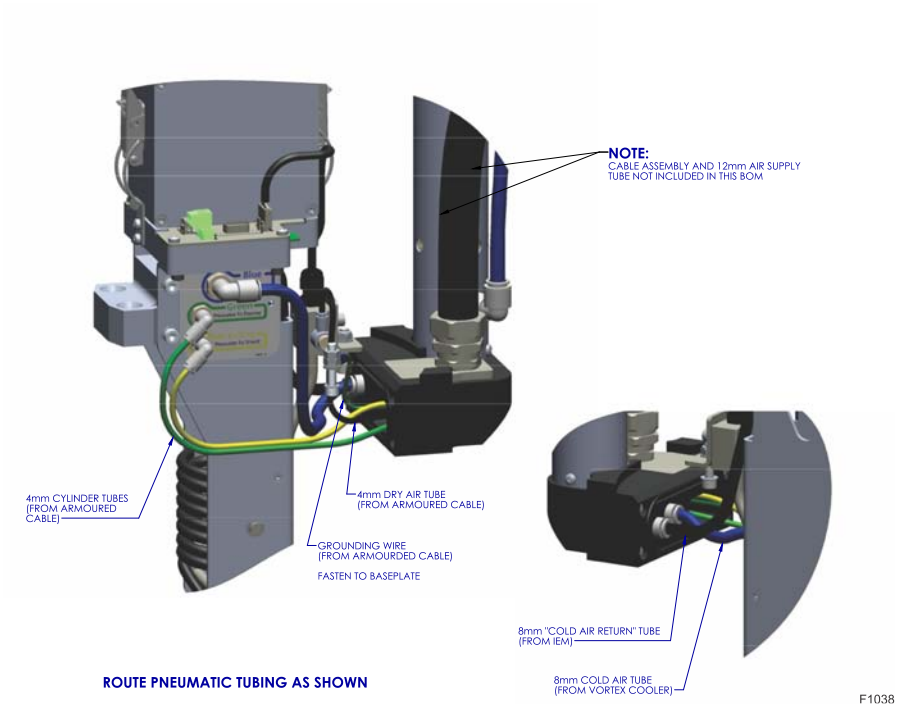


Figure 5-16. DPA pneumatic tube connection diagram

DPA installation (Commissioning)

The following steps describe the how to install the DPA correctly in to the probe lower shroud. This information is for reference only as this should be performed by a TFS FSE only.

Table 5-3. Installing the Detector Positioning Assembly

Step	Action
1	Remove the upper shroud by loosening the M12 bolt located on top centre of the upper shroud. This bolt is encapsulated so it cannot be removed from the top plate. Remove the upper shroud and place upright on a clean surface. **Note:** In order to protect the LED beacon connection assembly, do not store shroud upside down as this will expose PCB connection surface to any splashing or ingress that may settle and result in a failed connection.
2	Pull the swing bracket down as follows: 1. Pull out the spring loaded plunger located on one side of the hinge and hold with one hand. 2. With the other hand firmly lift the bracket up and swing over gently with the plunger held out. Do not force bracket over without lifting bracket off rest position first.
3	Remove the two tapered M8 nuts from the studs located on the swing bracket assembly and gently lower the detector positioning assembly into the lower shroud. Check that the assembly is resting on the bottom locating cones by removing the front window assembly and checking that the assembly is firmly in place when pushed in gently. (An unseated assembly will rock forward or back when pushed.)
4	Replace the two tapered M8 nuts with firm finger tightness. Tool tighten both nuts with a further half turn
5	Connect tubes and wires as follows: Connect 4mm green tube to upper bulkhead push fitting. Connect 4mm yellow tube to upper bulkhead push fitting. Connect 4mm black tube to dry air tube block push fitting. Connect 8mm black tube from the termination block to elbow fitting under the breakout board enclosure. Connect 8mm blue tube from termination block to the 8mm bulkhead on the side of the DPA assembly as shown on label. Connect all wires as follows: Connect D15 on to breakout board Check earth cable is connected to earth lug on baseplate.
6	Fit Detector Electronics Module as follows: Locate co-axial cable from break out board assembly and inset into the bottom of Detector Electronics Module co-axial connector. Fit Detector Electronics Module to breakout board assembly by carefully matching up male and female connectors. Press enclosure down in to place and engage toggle latches.
7	Lift swing bracket up into place until it locks in a vertical position. Once locked push down on bracket gently to set position.
8	Ensure the large base plate o-ring and the base plate area around it is clean from any dirt or ingress. Wipe with a damp cloth if necessary. Fit the upper

Step	Action
	shroud to the base plate avoiding catching any loose wires. Fasten with the stainless bolt in the top centre of the cover.. When upper shroud is pressed down. Tighten bolt until bottom of cover is touching steel base plate. Then tighten by at least ¼ of a turn. If the weather is above 30°C, tighten by ¾ of a turn to allow polymer to contract in cold weather and still affect a water tight seal.

Pneumatics box external connections

Due to the MSA shipping method, many of the pneumatic and electrical connections to the carriage pneumatics box will have been disconnected. Once the carriage assembly and MEP-300 probe are in place, these pneumatic and electrical connections can take place; Figure 5–17 shows the cables and tubes that connect to Pneumatics box. All pneumatic/water connections from the carriage to the pneumatics box should all be terminated from the factory however all other labeled connections will need to be terminated on site.

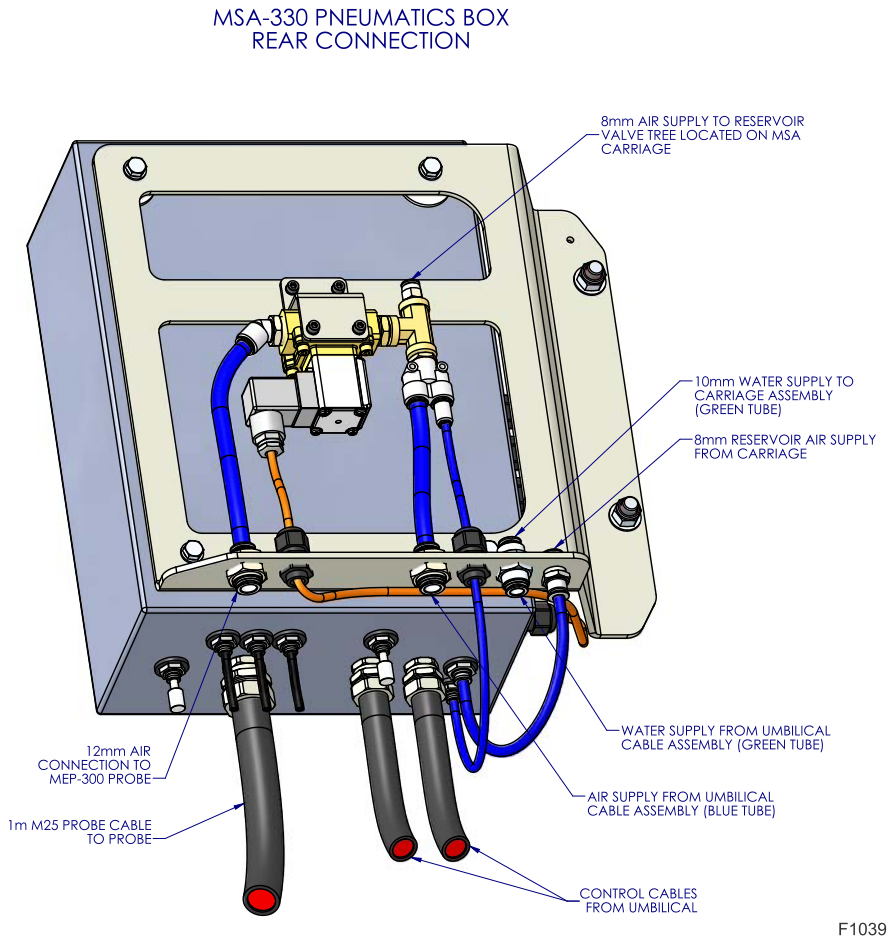


Figure 5–17. MSA-330 Pneumatic Box rear connections

Connecting the Probe and Controller

Installation of the MEP-300 itself is usually the last stage of system installation; when all the mechanical and electrical installation is finished. The MEP includes a rugged rubber lined stainless steel outside casing (lower shroud), the detector and the upper cover. The detector and its associate parts are housed entirely inside this two part enclosure.

The cable that connects the AM234 Probe (MEP-300) to its Controller takes the form of flexible conduit with two plug ended cables and three pneumatic tubes running through it. There is also a flexible PE conductor and even the space in the conduit between the cables is used to carry vented air used to keep moisture from condensing inside the Probe. The cable assembly is thirteen metres long over the flexible conduit.

The MEP-300 probe is connected to the controller via two independent cable assemblies connected in series with the carriage pneumatics enclosure acting as a junction box. The probe cable is 1.0 metre long and is connected between the probe and carriage pneumatics enclosure. The cable used between pneumatics enclosure and the controller enclosures is a 13 metres long coiled “umbilical” cable.

Network capabilities of the MSA-330

Communication with the Thermo Scientific MSA is via a 10/100 Ethernet port on the Embedded PC inside the Controller. A 4-port switch is provided at the bottom on the controller cabinet to assist connecting the network. One port is used by the EPC, another for connection to the Probe. Its purpose is to interact with the central computer(s) running the Thermo Scientific WinISA software. All four ports are physically interchangeable.

Connecting the MSA to the Central Computer

The MSA Controller M Panel is to be connected to a network, or directly to the WinISA computer. The maximum length for any Ethernet cable segment is 100 metres. If the cable run is longer than this it must be routed through an intermediate Ethernet Switch or extending device. . This decision will be the domain of the Client’s Information Technology (IT) department.

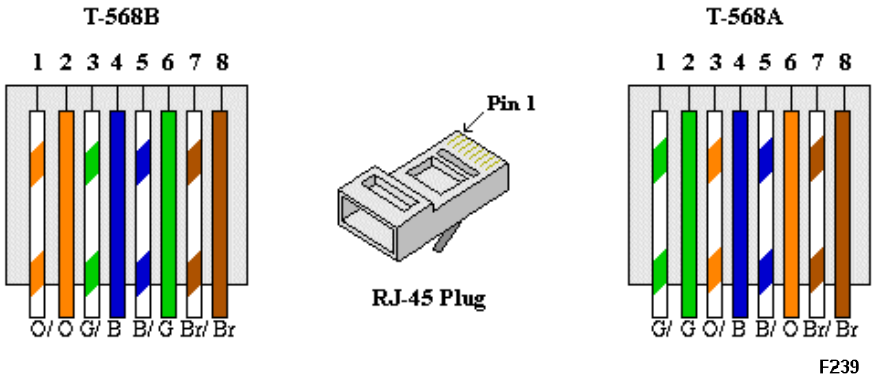


Figure 5-18. RJ45 connections

The cable should be unshielded or shielded CAT5e/6 twisted pair cable (shielded cable is normally used if the cable will likely be subjected to significant electromagnetic interference). Solid core cable should be used, rather than stranded for this type of installation – ensure that an appropriate RJ-45 plug is used, and terminate as shown in Figure 5-18. Either the T-568A or T-568B standard may be used – it is suggested to use whatever standard is already in use at the site, to avoid confusion. Make sure that whichever standard is used, the cable must be terminated the same at each end.

If the cable will be buried underground, suitably rated CAT5e/6 cable should be used instead of normal cable. If any part of the cable will be exposed to sunlight, either conduit that section or choose cable stock with a suitable UV rating. The effective communications can be tested by pinging the PC at one end from the network 100 times and ensure that the transmission is successful at least 99% of the pings; e.g. from a command line in Windows, by typing:

```
ping xxx.yyy.zzz.aaa -n 100
```

This will test the connection 100 times, where the 4 triplets of digits define the target computer's IP address.

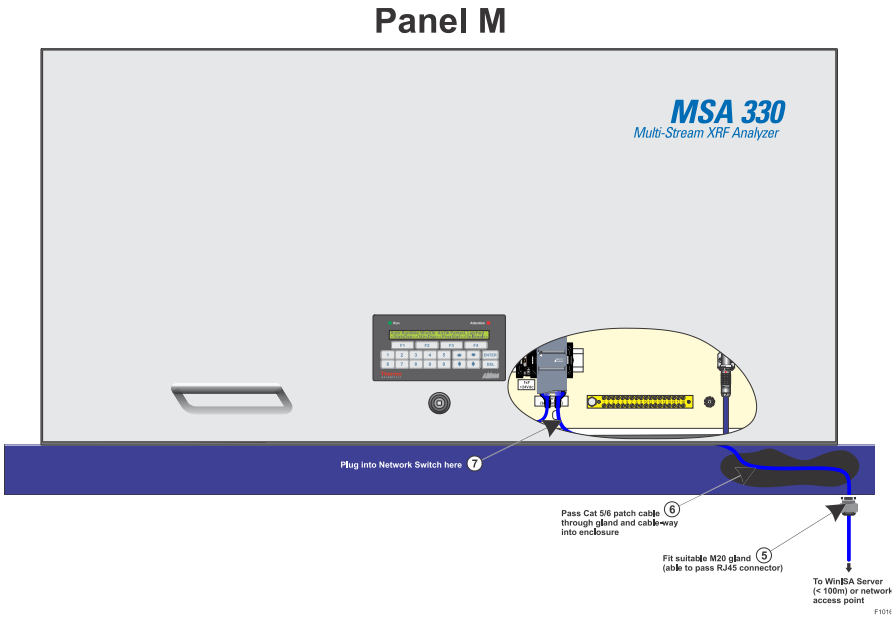


Figure 5-19. Ethernet Connection to the EPC in Panel M

Fibre Optic connection

Any media converter or other technology that may be required to use fibre optical cable for the link back to WinISA must be mounted outside of the Controller. Thermo Fisher can offer a suitable option known as the Thermo Scientific FxP. The FxP is a heavy duty IP65 enclosure (and optional power supply) that can house the majority of third party media converters. It includes a compact splicing tray and can be powered from the MSA-330 Controller or any mains voltage up to 500 Vac.

The Embedded PC (EPC)

This is a modular control system (Embedded PC) mounted on DIN rail. Its components are plugged together and installed in the control cabinet or junction box, depending on the required function. The modules of the PFC200 series system are connected with each other via the standard PC104 bus (16-bit). The individual system components are modules that can be arranged in series. The basic unit consists of a CPU module (Part no. 77920). See Figure 5-20.

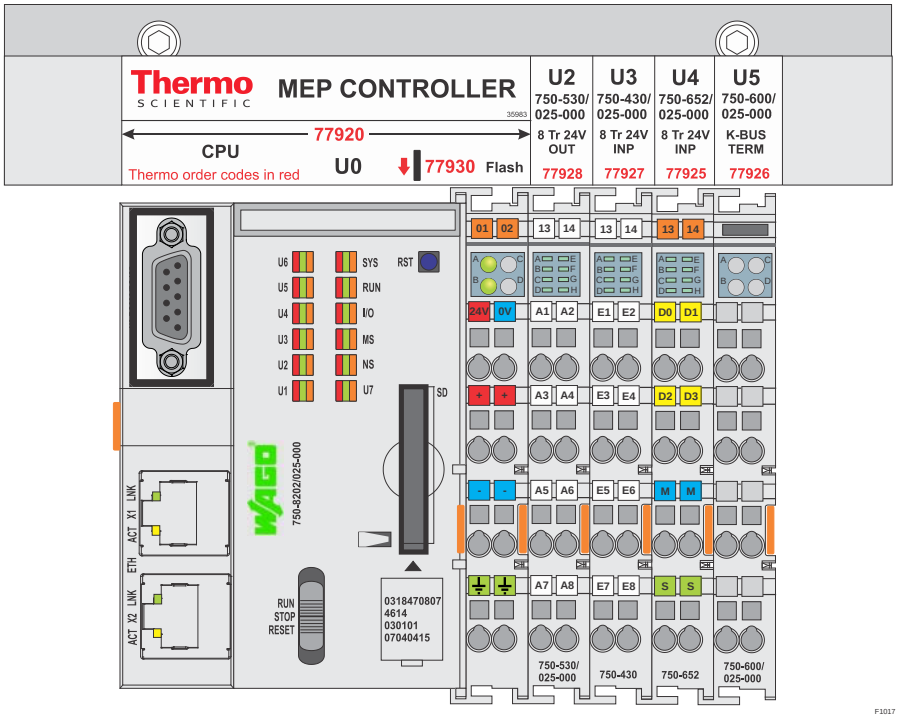


Figure 5-20. The EPC used in the MSA

System interface configuration:

a. Two(2) x Ethernet and one(1)x RS-232/RS485

The EPC comprises the CPU, internal flash and industrial rated SD card (P/N: 77930) for application memory. Two Ethernet and an RS-232/RS-485 interfaces are included. A required serial communication adapter for full duplex RS-422 interface is added at factory (P/N 40020).

FIG 4-21.1: Ejecting the CF card

FIG 4-21.2: Removing the CF card

FIG. 4-21.3: Inserting the CF card F305

Figure 5-21. Removing and replacing the Compact Flash (CF) card.

A Compact Flash memory slot is provided at the front of the basic CPU module. This enables an additional Compact Flash memory medium (format I or II) to be operated. Activating the eject mechanism by opening slot and pressing SD card allows removal for software maintenance. If the card is pushed in, the eject mechanism will re-engage. Refer Figure 5-21.

Central Computing Requirements

The central computer(s) supplied by Thermo Fisher to run WinISA shall be installed in a clean, dry room such as an operator control room or a specialised equipment room.

Warning Unless otherwise authorised, do not hook up or even unpack the central computer and peripherals. This will be done during commissioning by your Thermo Scientific customer support engineer (CSE). ▲

Note Provision must be made for the plant operators to view and access on-line display screen either on the master computer or on additional networked PCs or via a connection to a process control system screens. ▲

Any Thermo Fisher supplied computer will have the operating system and WinISA software already loaded. Otherwise, the software will also

need to be loaded first, before it can be configured and this will be done by the Thermo Fisher CSE during commissioning on site.

Installing Slurry Samplers and Pipe Work (if required)

The MSA is normally sized so that it can handle the full flow of the slurry stream it is being installed in. In some cases primary samplers are used to provide a sample to the MSA. These guidelines cover these cases.

The slurry sampling and transportation system, if required to feed an MSA is often the highest maintenance cost and downtime component. The maintenance costs and downtime can be minimised by careful design and implementation of this system. The following guidelines provide a brief discussion of the main issues which should be considered when designing and building this system. Thermo Fisher can provide more specific details and can provide the detailed design of the system if required.

The most important points are:

- The number of additional pumps required to transport the slurry streams around the plant should be minimised. Use should be made of gravity flow and line pressure wherever possible to transport the slurry to the MSA. The return line should be returned to the process via gravity flow where possible.
- The distance from the main streams to the MSA should be minimised. This will reduce blockages and the need for pipe replacement.
- The samplers, pipe work and analyzer should be readily accessible in case of maintenance.
- Determine what type of sampler is best in consultation with Thermo Fisher. The type of sampler used and the position of the sampler will determine where the MSA must be placed in the plant (see the next point). Therefore it may be necessary to look at a number of different options for the location and type of the samplers in consideration of the location of the MSA before making a final decision.
- The location of the MSA (both elevation and plan position) is determined by consideration of the following:
    - Enabling gravity flow to and from the analyzer;
    - Minimising the length of all of the gravity flow lines to and from the analyzer.
    - Minimising the number of extra pumps required in the sampling delivery system.
    - Access requirements for both operation and maintenance.

- General cleanliness of the intended installation area e.g. excessive splashing from above can contaminate shift sampler.

- The pipe work should be designed to minimise maintenance. Design rules are provided in section Guidelines for Slurry Sampling Pipe Work in this chapter.

Note The most important considerations are that the sampler provides a truly representative and unbiased sample of the slurry stream and that the sampler is reliable and is easy to maintain and use. ▲

Primary Sampler (if required)

Where it is not possible or practical to install a full flow MSA other samplers may be used for the Primary stages. These samplers may not provide a metallurgical balance quality sample. Advice should always be sought from Thermo Fisher before using these samplers.

There are several types of primary samplers available and the particular type selected depends on the application. For primary sampling of pipes that transport slurry there are basically two common types of primary sampler and these are the type usually supplied with the MSA if the expected full flow volume (m3/hr) exceeds the tank rating.

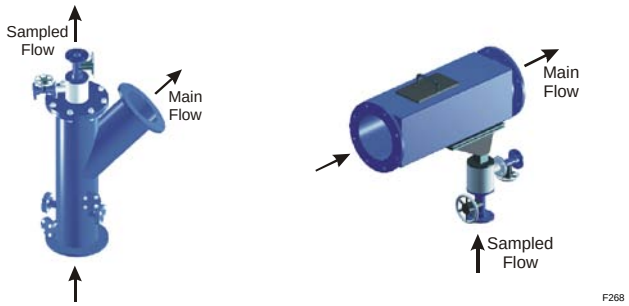


Figure 5-22. Primary Samplers

In-line Pressure Samplers

These are normally installed vertically after the pump discharge.

The sample stream flow-rate from a pressure pipe sampler is a function of:

- The internal diameter of the sample nozzle (which can be changed);
- Pressure in the main line at the sample outlet and the pressure drop between the sample outlet and the analyzer.

The internal diameter of the sample nozzle and the pipe-work between this and the analyzer must be selected so that the Pressure Pipe Sampler will provide the required flow-rate which must not be more than the maximum allowable through the analysis tank.

In-line Gravity Flow Samplers

These are a fixed cutter sampler fitted in horizontal or near-horizontal gravity flow lines. Representative samples are extracted through vertical cutters.

A gravity type sampler (horizontal fixed cutter or launder sampler) is normally installed on a near horizontal slurry pipe or launder which is carrying the full slurry stream. The outlet from the sampler flows under gravity to either the analyzer or to a pump which then pumps it to the analyzer.

This type of sampler can be used in all gravity flow situations in a pipe where the sample can flow directly down to the analyzer or where a pressure pipe sampler cannot be installed. A gravity sampler generally has a 50mm (2") NB sample outlet (flanged) and so a pipe line with the same or larger NB size should be used.

Note Primary Samplers supplied by Thermo Fisher are to be installed along with any associated pipe work by the Customer. ▲

Primary samplers provided by Thermo Fisher or manufactured under design recommendations from Thermo Fisher will incorporate valves and fittings for back flushing the sampler in the event that it becomes blocked. If applicable, drawings of the Primary Samplers are in Appendix D.

Slurry Pipe connections to the Analysis Tank

The Customer is to provide the slurry pipe lines to and from the MSA and provide and install any sampling equipment that may be required for these slurry lines.

The inlet and outlet pipes and flange sizes on the MSA are shown in the drawings provided in Appendix D.

All slurry inlet pipes (both horizontal and vertical) should discharge below the slurry level in the inlet section of the analysis tank; this avoids splashing that may generate air bubbles, particularly in frothy slurries. This inlet discharge pipe is already fitted in MSA with flange type compatible with table ‘D’ Australian Standard and ANSI, or as specified in drawings in Appendix D.

Guidelines for Slurry Sampling Pipe Work

If Primary Samplers or additional pipe work to transport the samples to the analyzer are to be installed, Thermo Fisher recommends the sampling pipe work is installed in accordance with our recommendations below.

Note Thermo Fisher highly recommends consultation with its engineers during the design of the sampling system to be used with the

analyser system as incorrect sampling system design may result in poor performance. ▲

Pipe Work Design

Pipe work from the sample point to the analyzer and from the analyzer back to the process should be designed to minimise blockages and maintenance.

The main requirements are:

- To supply a sufficient flow-rate of slurry to the analyzer.
- The transport velocity must be high enough to avoid sanding.
- Line/piping diameter must be large enough to pass the largest object in the stream.
- Must be reliable with minimal maintenance.

Pipeline Size

The size of pipes is determined by the flow-rate required, the velocity required to avoid sanding, the pressure or head available to drive the slurry and the maximum particle size that needs to be transported.

As a general rule of thumb, the minimum pipe size for pressure lines should be 3 times the maximum particle size going to the grinding circuit. For example, if this maximum particle size is 16mm, then the line size should be 3x16 = 48mm or 50mm NB.

Slurry Velocity

For Pressure Sample lines, the minimum slurry velocity in the line must be at least twice the settling velocity of the densest, largest particle of solids in vertical lines.

As a general guide, most base metals plants require a minimum line velocity of 1m/s.

To allow for surging of the plant and for pump wear, a minimum of 1.5 m/s is normally used in designing the pipe work. With velocities above 1.5 m/s in small lines, head loss increases rapidly so always keep line velocities as low as possible to minimise pumping power and to reduce wear.

For gravity flow lines, the velocity should be at least 0.3 m/s to avoid settling and blockages. These lines should have the maximum possible slope to ensure this.

The velocity of flow required to transport the slurry in the sample line depends on the particle size, the specific gravity, the percent solids (dilution) and the shape of the particles.

A minimum slope of 5 degrees will usually cater for most products. However, Thermo Fisher recommends the Customer performs test

work or models their particular application to determine the minimum slope required for their particular product.

Installation of Pipe Lines

The pipe work should be designed to avoid settling and blockages and should be self-draining on plant shutdown.

Sagging should be avoided. Not more than half a pipe diameter is recommended. The lines from a pressure sampler should reach the highest point soon after the sampler and then go steadily downhill from that point to the analyzer unit. The line from a gravity sampler should drop vertically initially and then only go steadily downhill to the analyzer. In all lines avoid bends as much as possible and **do not** use sharp or small radius bends - only use long sweep bends.

Particular care must be taken with supporting of non-rigid pipe like HDPE (high density polyethylene).

Warning Avoid tight bends in slurry pipe lines, as they will cause regular blockages. ▲

Siphoning

In some cases unwanted siphoning may occur so this should be engineered out if necessary.

Sampling Pipe Line Length

The sample line length should be minimised, particularly for coarse streams (i.e. P80 + 150 micron).

Sampler Back Pressure

The sample line should have less back-pressure due to friction and head losses than in the main line. This is required to ensure that a stagnation zone does not occur just upstream of the sample cutter in the main line, in which case the sampled stream would ***not*** be representative of the full slurry stream. This means the sample line ***must not***:

- rise as high as the main line (applies to Pressure Samplers only);
- have any constriction which has a smaller diameter than the diameter of the sample point itself - the pipe diameter should preferably be slightly larger than that of the ID of the point of sampling but not so big that the flow-velocity decreases to a point where settling may occur;
- have sharp bends (to minimise friction losses, wear and blockages) and should preferably have line-of-sight straight sections with a minimum number of curves with the largest reasonable radius of curvature.

Sampler Flushing Point

For Pressure Samplers, a water injection point (pipe stub with fitting) should be provided just downstream of the sampler so that the line can be cleared by back-flushing with high pressure water in case of blockage. A valve is required on the stub and also on the sample line downstream from the stub. The pressure sampler design includes a flushing valve option.

If a Gravity Sampler does not contain an inspection port which can be used for clearing the sampler itself, then a water injection point (pipe stub with fitting) should be provided just downstream of the sampler so that the line can be cleared by back-flushing with high pressure water. A valve is required on the stub and also on the sample line downstream from the stub. The gravity sampler design includes a flushing valve option.

Note Avoid using a valve to limit flow volume. ▲

Chapter 6 Calibration and Standardising

This section provides the basic information needed for Probe Stability testing (standardisation) and to calibrate an in-stream analysis system incorporating a Multi-Element Probe (MEP).

It assumes that Metallurgical Samplers are fitted to the MSA. Samplers are supplied as standard on all 330 models. The software manual should be used in conjunction with this manual for specific details about standardising the Probe and calibrating the analyzer using the WinISA regression analysis software program (RARP).

Overview (Standardise)

The MEP must be stability tested and standardized *before* calibration begins. This testing serves two purposes, one is to performance test the system to ensure that the probe and electronics are stable and secondly to provide the reference mean count-rates (*standard counts*) required for source decay compensation. The *standard counts* are used in *calibration* as well as in *trouble shooting* the system.

Note There is an additional internal Standard which provides another reference for maintenance purposes. Its count-rates should not be used in standardizing the probe. ▲

Stability Testing (Standardising)

The procedure is done with the standard biscuit in place and for up to 12 hours or overnight where possible.

The following procedure shows how to measure the *standard count-rates* and run a *stability test*.

Raise the probe from the slurry by pressing the yellow PARK button on the MSA frame. If the probe parks down in an active AZ (i.e. one with slurry or water in it, then press the green RAISE button to lift the probe clear of the liquid. Refer Figure 7-7 for front panel controls. The internal source and detector should also rise to shielded position as indicated by a green ring of LEDs around the top of the Probe. Do not press the STANDARDIZE button yet.

Wash and dry the probe head and window. If the window is scratched or dirty after cleaning it should be replaced, because a dirty window will adversely affect the standard counts you obtain. See Replacing the Probe Window in Chapter 8.

Check the biscuit is clean, and then place the standard biscuit on the probe. Make sure that the correct standard for that probe is used otherwise the standard count-rates will be worthless. If there is likely to

be slurry splashing onto the probe then encloses the bottom part of the probe leg (Figure 6-2) in a plastic bag over the biscuit and clip. A zip-tie or rubber band should be used to hold the bag in place.

Press the white STANDARDISE button (see Figure 6-1). This button should illuminate indicating that the probe is in fact in standardise mode. A message to that effect also displays on the WinISA screen. Refer to the Software Manual for additional details.

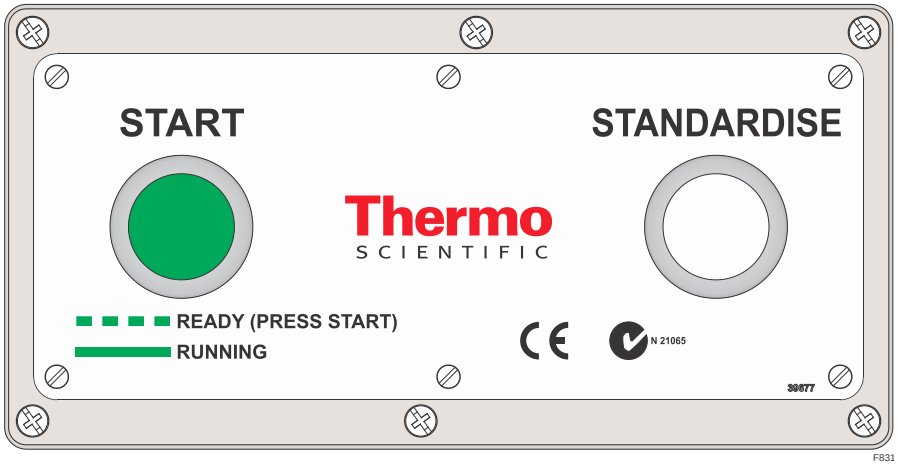


Figure 6-1. The MSA 330 (RE) START and STANDARDISE buttons

Note There is an additional preparation required for the first standardisation. This will involve at least an hour per analyser stream renaming tags in the WinISA database. ▲

Once the standardisation has been started the first time, the installation engineer will need to define the Regions of Interest (ROI) using the WISP application. The ROI names will need to be transferred to the names of the ROI registered in the WinISA database.

In addition, the Assay names will need to be agreed and assigned in the WinISA database at this time also.

After the ROI and assay names for each stream have been saved, WinISA will need to be stopped and restarted so that the names are used in the Stability files headings.

Caution Do not remove the biscuit at any time while the STANDARDISE button is alight. The internal radiation source will lower periodically (with the detector) during standardization. This will result in X-ray emission if the biscuit is not present to block it. ▲

Bring up the count-rate tabular display and wait at least 5 minutes for the first count-rates to appear (default counting time is 300 seconds in

standardise mode). If they don't appear then check you are configured properly for standardise mode. Refer to the Software Manual for further details.

Leave the probe standardising for about 24 hours, if possible, or at least 12 hours.

Note Assays are not produced when a probe is in standardise/stability mode. ▲

Figure 6-2. Standard Biscuit on an MEP300

At the end of the standardising period release the STANDARDISE button to terminate standardise mode. Wait until STANDARDISE button lamp is off before removing standard biscuit.

Remove the plastic bag (if present) and standard biscuit and return the MSA to service by releasing the PARK button. Check that the OI confirms it is back in Auto and the green START lamp is on solid. If it is flashing, press it briefly and it should stay on. The MSA has returned to normal operation using the normal analysis time.

Caution Be cautious if removing the biscuit while the Probe ring beacon is amber The source is not confirmed shielded unless the beacon is green. ▲

Run the "Stability" software program to produce a tabulated summary of the standard count-rates and stability statistics. The Software Manual provides details for running this program, where to find the database files and how to interpret the data. If the standard count-rates fail the stability test then investigate why before proceeding with Calibration. This may require re-running the test.

If the standard count-rates pass the stability test select the "Apply" button on the summary panel in the stability program and the mean count-rates will automatically be entered into the software configuration as the "Standards".

Note if the stability test reports any unstable channels, the reason should be investigated and resolved. Then retest and restandardize the MEP300. ▲

Note Note if this is the first time the probe is being standardised, the default standards will be 1, so the measured standard counts will be inconsistent. Therefore you *should* override the defaults with the measured standards. ▲

You are now ready to start calibration but first check that your Metallurgical Samplers work correctly by making a few cuts into a bucket using the SAMPLER switch.

Overview (Calibration)

The analyzer system must be calibrated when it is first installed and commissioned in the plant. Calibration involves the taking of *at least* 30 samples from the stream to be calibrated. These samples are then chemically assayed in a laboratory either on-site or elsewhere and the assays are then correlated with the corresponding count-rates from the probe that were measured during the period that the sample was taken, usually this is five minutes.

Note The analyzer must be standardised before calibration begins and the Assay names used to rename the default Assay labels. ▲

To obtain calibrations for the analyzer system, count-rates measured from each stream are correlated with analysed mineral content and density using a multiple linear regression analysis application. When a suitable calibration is obtained its performance is checked by comparing the calculated values against the observed assays for subsequent samples, using statistical and plotting routines.

The "line of best fit" to the data is determined by the method of least squares for a number of selected functions. The results are obtained as a

plot of calculated values for each dependent variable against the values obtained by analysis.

Software configuring is needed to enable on-line measurements from the analyzer to be automatically appended into the calibration data file for each stream t being calibrated. The file type and name is "Calibration.DBF" for every stream and they are found in the directory folder created during initial set-up for each stream. This file also contains the standard count-rates and these are updated each day that calibration data is added to the file.

It is important that standard count-rates are obtained before starting calibration and that these are entered into the software data base so that they can be automatically added by the software to the "Calibration.DBF" files during the calibration phase.

Calibrating an MEP involves the following steps:

- Taking a suite of at least 30 *Calibration Samples* from each stream using the built in sampler by selecting **Cal** (calibration mode) at the Operator Interface.
- Preparing the samples by filtering and drying.
- Chemically assaying the *Calibration Samples*.
- Entering the Data into Calibration Files for analysis with the RARP software program.
- Running regressions to find the best Calibration (Assay) Equations, including interpreting the results and applying the equations.
- Checking and maintaining the accuracy and reliability of the calibration equation.

Each of these steps is covered in this chapter.

Equipment and Resource Requirements

The following items are required for calibrating the MSA-330 probe:

- 20 or more clean buckets of at least 10 litre capacity, with lids. Each bucket must be weighed, without its lid, to 0.1g accuracy and the weight written in permanent pen on the bucket.
- Efficient on-site *Sample Preparation Facilities* and personnel to handle at least 30 samples per analyzer (stream) to be calibrated over a period of up to two weeks, depending on the plant variations and scope of work. Typically, up to ten samples per stream per day will be taken. For example, 6 streams will require *at least* 180 samples in total to be taken in a period of up to one (1) week then further samples would be taken to check the calibration accuracy and reliability.

- Equipment and resources required for sample preparation shall include:
  - pressure filters, (approx 10 litre capacity)
  - weighing scales to at least 0.1 g accuracy and capable of weighing up to 5 kg (wet) samples
  - efficient sample drying ovens or lamps
  - sample trays and sample bags
  - log-book for sample information and tracking
  - personnel to prepare the samples

Note The %solids of each sample must be measured with an accuracy of better than +/-0.1 %solids using the wet and dry weights method. ▲

- Chemical assaying facilities, either on-site or off, to provide chemical assays for all required elements from all the calibration samples. The total turn-around time including sample preparation must not be more than 48 hours so as to minimise the time required to calibrate the analyzer system. Usually analysis would be required for between 20 and 40 calibration samples daily. Because the analyzer accuracy is dependent on the chemical assays then the error associated with the chemical assays and sample preparation of the samples must be as small as possible.

Note Chemical assay accuracy must be better than one third of the expected accuracy of the in-stream analyzer at 1standard deviation(1s..d.) to avoid contributing to the apparent errors of the analyzer. ▲

Note Please familiarise yourself with the instructions in the software configuration section of the *Software Manual* before attempting to take samples. ▲

Taking Calibration Samples

To obtain a calibration that will work for all plant conditions the samples must cover the complete range of plant operating conditions where possible however this is neither normally possible nor practical during a commissioning visit and may take many weeks or months. Hence, during the commissioning and calibration period plant personnel are trained in all aspects of the calibration process so that they can continue maintaining and updating the calibrations where necessary.

For correlation, the samples must correspond with the timed measurements of the analyzer itself. The measurement is usually

performed for five minutes and this is taken care of by the built in calibrate mode of the analyzer.

Taking Samples

The steps you need to go through to gather useful samples are as follows:

1. Place a clean and dry tared[1] bucket under the end of the blue Sampler tube of the stream(s) being calibrated.

2. Ensure the sample selector switch is set to "AUTO". Then go to the OI panel and select the menu option **<SelSampler>** and enter the stream number that you want to calibrate.

3. Now select the sampler mode **<SmpMode>** and choose **calibrate**. Select "yes" to the **change bucket** prompt. When the probe next visits the zone, and WinISA starts accumulating counts for that stream you will see the "Taking Sample" message.

Note Be aware of the probe sequence when requesting calibration samples. ▲

4. A pre-defined number of sample cuts will be automatically taken over the measurement period. This number is defined in the WinISA software. Should there be too much or too little sample collected, you may choose to alter the number of cuts or the speed of the sample cutter. The latter is set on the Sampler Speed Selector Switch located on panel L. In most cases the laboratory will require at least 100 grams of solid for assaying.

5. When the sampling or measurement period is finished the OI panel will display **Sample Taken** and the sampler will revert to **off** mode. If the analyzer has been set to take shift samples ensure the sample selector switch is left set to "AUTO" (i.e. do not turn it off) and select **<SmpMode>**, **Shift** after replacing the shift sample bucket.

6. At the end of the period the number of cuts taken by the sampler will be checked by the software. If all is okay the calibration sample count-rates will be saved automatically in the calibration data file (Calibration DBF) for that stream.

7. Write that end time (+/- 1 minute is accurate enough), date and sample stream name on the bucket or a tag affixed to it. If you have more than one bucket in the plant, take care not to mix them up!

---

[1] "Tared" does not mean *coated with bitumen* in this instance.

8. Place the lid on the bucket and carefully take the sample to the laboratory without spilling or otherwise contaminating or changing the nature of the sample. Record sample details in the log sheet in the metallurgy lab.

You will now have a single composite sample which is representative of the sample flowing through the analyzer during the calibration measurement period. The sample will normally contain between one and five litres depending on the flow-rate, the opening of the sample cutter (10mm is standard), the speed and frequency of cutting the stream, and the sampling period.

Rules for Calibration Sampling

The rules for calibration sampling are:

- The complete set of calibration data must cover all of the range of conditions which occurs in the stream. For example, the samples must cover the whole range of elemental concentrations, mineralogy and matrix variations as well as variations in the density of the stream. If the samples do not cover these ranges, then the analyzer will affect the accuracy of results during these conditions.
- It is important to keep in mind that the calibration equation has been made for the particular operating conditions covered by the samples in the data set. If a new set of conditions is encountered, the accuracy of the analyses from the calibration equations will deteriorate. In other words, accurate analyses can only be expected when interpolating within the range of conditions represented by the calibration data.
- Calibration samples must be collected and analysed with the maximum of care to avoid contributing to errors in the calibration equations. A poor result from the regression analysis should not be blamed on the analyzer without a thorough investigation of all of the procedures used in obtaining the calibration data.

Note If the equations are giving inaccurate results, additional calibration samples should be taken and added to the calibration data set and new calibration equations should be found which cover the new operating conditions. ▲

Assaying the Calibration Samples

Each sample must be chemically assayed for the required metal concentration (by %weight) and its percent solids calculated.

- The “%solids” of the sample is best measured by the wet and dry weights method so to start with, the sample must be accurately weighed in the bucket before it is dried. Don’t forget to take the bucket lid off if the bucket weight was measured without the lid on, otherwise leave it on. Try to use the same weighing scales as are used to tare the buckets.

- Weigh a number of clean filter papers, if using a pressure filter to filter the samples and write the weight to one decimal place on the outside edge of the paper. It is best to use very fine filter paper, especially where fine milling is carried out as there may be a large percentage of slimes in the samples to be filtered.
- Filter the sample to remove most of the water. This is best done in a pressure filter as it is far quicker and more efficient, but the method chosen will depend on what gives the best result for the particular slurry. If there is a large amount of slime in the sample (evident if the filtrate is collected) then collect the filtrate from each sample and pour it back on top of the filter cake so as to minimise errors in the final assay that may be due to slimes loss.
- Dry the sample: Put the filter cake (sample and paper) onto a metal tray or dish and place in an oven or under heat lamps to speed up the drying process. However, care must be taken to ensure that the oven (or lamps) is/are not so hot that the minerals oxidise.
- Weigh the dry sample and then calculate the %solids remembering to subtract the bucket, tray and filter paper weights. Make sure that the samples are at ambient temperature before weighing so that air currents due to the heat from the sample will not distort the measured weight.
- Assay the samples in the normal manner in the laboratory. Sampling and analytical errors by the laboratory must be smaller than one third the expected error band of the analyzer otherwise they will contribute significantly to the total error of the calibration. Assays that the MSA is not required to produce are not required from the assay lab either.
- Enter the laboratory assays into your regression assay file as soon as you can. Refer to the calibration section of the Software Manual for details on how to create these data base files.

Definition of Terms used in Calibration

This section covers definitions of different Terms used in Calibration. They are Measurement Time, Standard Count-rates, Calibration Data, Assay Data, RMS Error, Correlation co-efficient and Relative Error.

Measurement Time

Regression Analysis uses the measurement time in calculating the reproducibility error in the assays (due to the reproducibility of the count-rates) for each equation. The reproducibility of the count-rates is dependent on the measurement time. The assay reproducibility is calculated at one standard deviation and is displayed in the output file as the “Stats Error”, meaning the Statistical Error. The measurement time is normally 300 seconds (5 minutes), but if you use a different measurement period, you can enter this into the regression program so it calculates stats error correctly.

The use of the measurement time arises with all nucleonic measurement equipment because the reproducibility of the measurements improves as the square root of the counting time. This means that if the count-rate averaging time is increased by a factor of four, the reproducibility of the result will improve by a factor of two. The "Stats Error" is used to evaluate whether the accuracy of the instrument is limited by the reproducibility of the count-rates or whether it is limited by some other factor.

If it is limited by the measurement time, then the time may be increased to improve the results. In practice, if the "Stats Error" is larger than half of the RMS Error (see definition in section RMS Error later in this chapter), increasing the measurement time of the instrument should significantly improve the RMS Error. On the other hand, if the "Stats Error" is much less than half of the RMS Error, the measurement time of the instrument may be decreased without significantly reducing the accuracy or reproducibility of the measurements. This would give a higher throughput of samples with the instrument.

Note For very low concentration measurements, increasing the measurement time may not be practical if the required accuracy demands excessive count times for the analyser. ▲

Standard Count-rates

The calibration equation always uses normalised count-rates. The count-rates are normalised by dividing the actual (on-line) count-rates in each channel for each sample collected, by the standard count-rate for each particular channel. The standard count-rates are automatically inserted into the calibration data file each day that calibration samples are taken. Source decay is automatically compensated for, providing source details have been entered into the WinISA software configuration (refer to the *Software Manual* for details).

The standard count-rate in each column of the "Calibration.DBF" file is used as a divisor for all subsequent count-rates in that column until a new standards line is encountered. Hence, all count-rates from the samples are normalised with respect to the count-rates from the reference sample.

The use of the standard line allows for long term changes in the performance of the probe due to such factors as source decay and detector efficiency. When the performance of the instrument changes the count-rates for any sample will change in the same ratio as the count-rates for the reference sample (standard). Hence, the ratio of the count-rates from the samples to the count-rates from the reference standard is always constant, independent of all other factors.

The data file may contain as many standard lines as required to compensate the data for changes in the efficiency of the instrument detector over time. Normally, Thermo Scientific XRF probes are stable for very long periods of time (i.e. years) so only a few standard lines are

required throughout the file (or for each new day when calibration samples are taken).

Note Assays are not expressed as a ratio and so no standards need to be entered into the assay file. ▲

Calibration Data

Each data line in the Calibration Data.DBF file corresponds with the measurement of one calibration sample. Each line begins with the sample's identification, consisting of a string of up to eight alpha-numeric characters. A Date/Time stamp is also included in each sample line. Then follows the count-rate data columns for each X-ray ROI (region of interest).

The first cell is left blank for each sample; this is where the sample's identification must be entered.

Standards lines will be inserted in between the calibration data lines. Each date change will show a new standards line when calibration samples are actually taken on that day.

Assay Data

Each data line in the "Assay.DBF" file corresponds with the laboratory assays for that sample. Each line begins with the sample's identification which MUST be the same as that used in the Calibration Data.DBF file for that stream. Enter lab assay values and sample id's using the RARP regression program. Refer to the *Software Manual* for details on setting up your assay data base files.

RMS Error

RMS Error is the standard deviation between the chemical laboratory assays and the instrument assays for a suite of samples and is calculated by:

$$RMS\ Error = \left[\sum_{i=1}^{N} \frac{(x_i - y_i)^2}{N-1} \right]^{\frac{1}{2}}$$

Where, N is the number of samples.

X_i is the chemical assay of the i^{th} sample.

Y_i is the assay from the instrument of the i^{th} sample using the calibration equation

In general, the equation chosen will have the lowest RMS Error of all possible equation forms (see other rules also).

The RMS Error is also known as the analyzer Calibration Error. This error is comprised of the following errors:

- Stats error (as described above under Measurement Time)

- Particle Size Error
- Mineralogy Error
- Segregation Error
- Sampling Error of the analyzer
- Laboratory Errors in sample preparation and analysis
- Other Instrument Errors such as electronic instability, dirty windows, etc.

The *Total Calibration (RMS) Error* is the square-root of the sum of the squares of all these errors.

Correlation Coefficient

The Correlation Coefficient (CC) is a measure of the linear relationship between the ISA predicted values and the laboratory results. The correlation coefficient is dependent upon the range of the calibration assays and the RMS error:

As the range increases, CC $\rightarrow$ 1

As the RMS Error decreases, CC $\rightarrow$1

If the correlation coefficient approaches 1, then you can extrapolate the ISA predicted assay values beyond the range of the calibration data set.

The limits for each assay equation should be set according to these criteria. However, it is always recommended that additional calibration samples be taken that “fit” the real operating range.

Relative Error

The Relative Error is defined as the RMS Error divided by the mean assay often expressed as a percentage. For a good calibration, the Relative Error should be less than 10% and may be as low as 1% or less. In general the higher the mean assay the lower the Relative Error.

Running Regression

Following is a general description of the Regression Analysis Program (RARP) that is used to find the best calibration equation for producing reliable accurate assays from your MSA.

The exact form of the best calibration equation depends on a range of factors such as the mineralogy, matrix and particle size of the material which is to be measured. Therefore, each analyzer has to be individually calibrated over the range of ore blends and operating properties so that it will give the best possible measurement accuracy.

To find the best form of the calibration equation, the regression program cycles through all valid combinations of equations based on the data from the suite of calibration samples. This information is then presented to the user who can then compare/reiterate or choose a particular equation terms. The best equation should be chosen based on

a comparison of the RMS Error, Correlation Coefficient, Relative Error and the Number of Terms used in the equation.

For each stream to be calibrated, the program uses the "Calibration Data.DBF" file for that stream to obtain the count-rate data and also uses the assay data base file that was created by the user entering the laboratory assays. The *Software Manual* provides further details on using the RARP program.

Regression program should be run on the WinISA server computer so chosen assays can be easily 'Applied' to the WinISA server configuration. If you run a regression on another computer, equations must be manually entered into the WinISA server configuration, using either the WinISA Delphi Client Configuration Wizard or the WinISA Panel.

Deleting Samples in the Regression

The user can delete some samples from a particular equation. The program allows the user to do this interactively by either:

- Examining the table of the residuals and selecting the point(s) with the highest residuals.
- Inspecting a plot of the calculated assays versus the actual laboratory assay. The plot helps you to see if there are any sample points which do not seem to fit the same relationship as the rest of the samples (i.e. one or two points are a long way from the calibration line formed by the other samples). In this case, the sample(s) in question may be incorrect in some way – either the data may have been entered incorrectly into the data file, the assay for the sample may be wrong, the sample may have been contaminated etc. Whatever the reason, the cause should be investigated and corrected if possible.
- Using the equations with samples already eliminated automatically by and presented to the user by the software program. It is recommended though that the user also manually checks the form of the equation and samples eliminated to ensure that the best possible equation is chosen.

The user can also reduce the range of the observed assays to obtain "better" equations in the operating range expected.

When all of the required samples have been deleted, the user can re-evaluate the regression and then print a copy of the result or post the equation chosen to the software configuration, by selecting the "Apply" button in the regression software(RARP), for immediate on-line use.

Note Normally no more than 10% of the sample points can be deleted without investigating further into the reason why so many samples don't 'fit' the regression line. ▲

General Rules for choosing the Best Equation

It is good idea to consult your plant metallurgist regarding concentration range and desired accuracy. They may also provide useful hints about correction terms based on mineralogy and/or ore blending and/or plant operating condition.

Other important rules which must be observed when choosing the best calibration equation for a particular application are as follows:

- Always make sure that the fundamental form of the equation is included when running the program. The fundamental equation relates the assay to the single most significant term. For example, the single most significant term in a calibration for %Cu is the copper count-rate (viz. CuKa). The results for the more complex equations can be compared to the results for the fundamental equation to see if there really is an improvement. Extra terms are often needed to cover different mineralogical forms.
- Always look at the plot for the fundamental equation form. If the plot shows one or two bad points on this graph, it is a strong (but not conclusive) indication that these data points are in error. If the same points are bad on the graphs for the more complex forms of the calibration equation and for other assays, then you can be much more certain that there is an error in the data for these points and hence you can eliminate them completely from the data set.
- Always ensure that the coefficient of the fundamental term has the correct positive or negative sign. In general, the fundamental metal count-rate term in an equation will be positive in sign.

For example, in a calibration for %Cu, the coefficient of the copper count-rate term should always be positive. In a density calibration, however, the coefficient of the scatter count-rate must always be negative in sign. If the sign is not correct, look at the data file to see if there is an error.

- In general, calibration equations should be based on at least 30 individual sample points. An initial calibration can use fewer samples as long as the number of terms is limited to no more than one tenth the number of samples.

Note In general, you should not need to use more than four independent terms in a calibration equation. ▲

- If the plot of the results of the best regression equation shows that there are a small number of sample points which do not fit the calibration as well as the majority of other points, you may want to delete them from the data set and re-run the regression. This will normally improve the calibration equation and may even give a better equation with fewer terms. Sometimes, one or two points are so far from the other points that there is likely to be an error in the data entered into the file and it and should be checked.

- Before deleting each point, first check that all of the data for this point has been entered into the data file correctly. If it is correct, then investigate further to find the cause of the problem. For example, you may want to have a couple of the samples including this one re-assayed. It is best if you can correct the data in this manner. After trying unsuccessfully to correct the data, you may then delete the point(s).
- Statistically, you may only delete up to 10% of the total number of sample points. If more than 10% need deleting to make the regression acceptable, there could be a problem with either the sampling method or analytical (chemical) accuracy. Eliminate all errors of this type before proceeding with the calibration. This is very important to ensure that the analyzer is calibrated with the best possible accuracy.
- Look for a 10% relative improvement in RMS Error before deciding to remove one more sample point, or to use an equation with one more term.
- Ensure that Statistical Error is less than half the RMS Error.

In summary, look for:

- low RMS Error
- low Stats Error ($^1/_2$ RMS or less)
- Fewer terms (must include fundamental)
- Positive fundamental term (except %solids where fundamental term is negative)
- Look for a 10% relative improvement in RMS Error before deciding to remove one more sample point, or to use an equation with one more term.

Checking the Calibration Accuracy

After the system has been calibrated, it should be checked periodically to ensure that the calibrations are producing the correct results particularly since initial calibration equations are only as effective as the range of ore types and operating conditions encountered during the initial calibration. This will require the building-up of data from calibration samples to cover as full a range as possible. Based on the results of the checking, it may be necessary to up-date the calibration (assay equation) and the procedure given here for checking the calibration accuracy should be followed.

Once or twice per week the on-line assays from the analyzer should be compared with assays from the laboratory to ensure that it is giving the correct results. It should be noted that it is best to take a calibration sample as a comparison sample over a five minute interval instead of using shift composites or two hourly grab samples. There are several reasons for this:

- Shift composite samples average out the normal fluctuations in the performance of the plant so they only give a fairly superficial comparison. The MSA operates largely independent of flow rate whereas a shift sample will be affected by flow rate fluctuations.
- Sometimes the shift composite sample is not a true average of the performance of the plant over the shift. This can occur if there is a major disturbance in the operation in the plant between times when sub-samples of the composite were taken.
- A sample taken over the measurement period from the stream being analysed corresponds exactly with the slurry which the probe was measuring over the same time period.

If you wish to use plant shift samples for the comparison, more care should be taken in interpreting the comparison between the shift results and the corresponding results from the analyzer such as comparing %solids, and monitoring flow rate fluctuations throughout the shift. If the analyzer is consistently displaying assays that are significantly different (outside the statistical normal distribution, see Comparing Check Samples with On-line Assays, below) to the shift samples, then extra calibration samples should be taken and new equations generated to fine-tune the calibrations.

Additional samples are taken and assayed exactly as per the procedures given earlier in Taking Calibration Samples and Assaying the Calibration Samples.

Comparing Check Samples with On-line Assays

The most effective method is as follows:

1. At the computer note the corresponding on-line assays for each sample from the each analyzer, at the (finish) time the sample was taken. This can be done by checking the tabular assays screen, or using the “Assay.DBF” file located in the same folder as the Calibration Data.DBF file. This option must be selected either during installation of the WinISA Delphi Client or set up in the WinISA Delphi Client ‘Options’ menu.
2. Record the laboratory and on-line assays and their difference.
3. Repeat steps 1 and 2 until at least 20 samples have been taken, and whilst running the same calibration equations for the stream being checked (otherwise your ISA reading may vary too much)
4. Plot the difference between the two assays, for each sample as you obtain the data, on a graph versus time. This graph should contain the results for all of the previous samples and so you will build up a graph that indicates the performance of the analyzer over a long period of time.

5. The plot of the difference should show a small scatter about zero such that around 67% of your check samples should fall within *one RMS* and around 95% within *two RMS* as per a statistical normal distribution. The scatter for the samples taken should be about the same size as the RMS error from the initial calibration. In this case, the calibration is good and the analyzer is operating correctly. Deviations from the ideal graph described above indicate a problem and a description of various symptoms and remedies is given with graph.

Note The error in the analyzer assay value is always ±*The Total Calibration Error*. A check sample that is analysed in the laboratory has an error ±*The Total Lab Error*. Hence, the difference between the two assay readings then has a total error of ± (*Total Calibration Error* + *Total Laboratory error*). In a well maintained system, this condition is true for 67% of the suite of check samples taken, 95% will be within twice this total error. If the check sample is added to the calibration, the total error is then inclusive of lab error. ▲

An alternative method is to calculate the RMS Deviation on the suite of check samples that you have taken and re-calculate this each time a new check sample is added. To use this method you will need to take at least 20 check samples.

The RMS deviation that you calculate on your check samples should be close to that obtained for the calibration, which is the assay equation that is being used at the time of taking the check samples. If not, then there is a problem with the operation of the analyzer and some further checks need to be done as per the remedies given.

Chapter 7 Operation

This section is written for those personnel who will oversee the daily operation of the MSA. It includes a description of the main components of the system.

The Thermo Scientific MSA uses a solid-state Multi-Element Probe (MEP) that can measure up to 20 elements and pulp density simultaneously. The in-built sampling system provides for representative sampling of the slurry for calibration of the MEP as well as metallurgical accounting samples.

Safety & Environmental Protection

This section covers the safety and environmental protection issues. Mainly it covers safety mode, radiation shielding, starting and stopping of the system.

Manual Mode

In the event that any operating conditions are abnormal (e.g. power failure, probe window rupture, air pressure failure etc.) the probe will be automatically lifted from the slurry by its pneumatic hoist to prevent possible damage to the probe's detector. The probe cannot be lowered until such time as the problem is rectified. The MSA will change to "manual" mode, preventing the probe from moving unexpectedly. Safety sensing circuits demand that the problem must be fixed before the MSA can be put back into automatic operation (i.e. "AutoMode").

A "Mains Isolator" switch is provided on Panel L of the MSA. It is interlocked with the enclosure door. As well as being an isolator this is and overcurrent protection device to back-up the multiple Motor Protection Circuit Breakers (MPCBs) that protect the internal branch circuits.

An Emergency Stop (E-Stop) latching press button is strategically located on the MSA. A quick hit on this button freezes all operation of the MSA unit, including stirrers and samplers. The probe will also freeze in whatever position it was when E-Stop is pressed. The MSA will also revert to the temporary "manual mode" and operation cannot resume until the E-Stop is released by pulling on it.

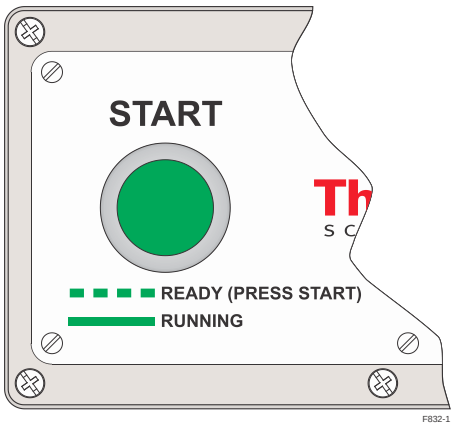


Figure 7-1. The START button

Even then it will not start immediately. As required by various safety authorities, it requires a further action – basically a (RE)START. This is achieved by pressing the green START button (Figure 7-1) which will be flashing as a prompt to someone to do so.

Manual Modes

There are two types of manual mode. They can be distinguished by observing the Operator Interface (see Figure 7-5). A running MSA will display "Auto" at the top left of its OI as shown in Figure 7-9. This means it is open to receiving commands from WinISA and moving the probe from stream to stream. It can be deliberately put offline, i.e., changed to Manual mode (note the capital "M") using the OI. This requires a password.

Now the MSA can be made to move any way – up, down or horizontally or go to a specific zone. It cannot be lowered, however, if it is not aligned with a tank prox. Once in Manual mode the MSA will stay that way even through a power down. It has to be put back into Auto using the OI again. This will require re-entry of a password in some cases.

The other type of manual mode is displayed with a lower case "m" (see Figure 7-5) and can be due to some form of error or because the probe has been parked. The MSA will recover from this state and return to "Auto" if the problem is rectified and/or the probe is "unparked".

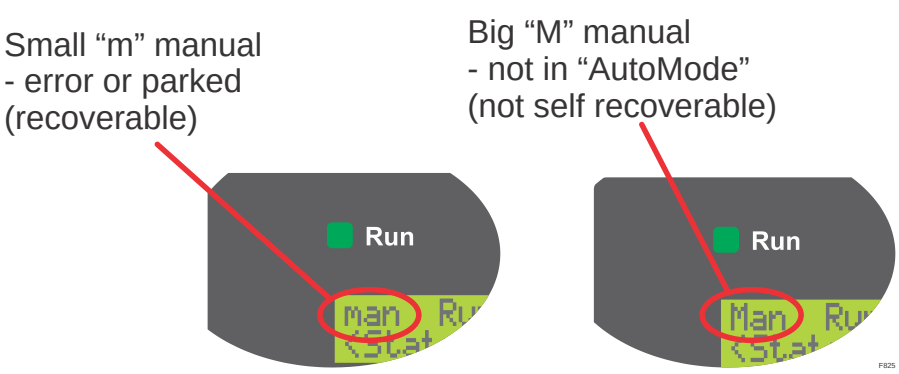


Figure 7-2. The two types of MANUAL mode

Stirrer Overload

MPCBs are provided for each stirrer motor. These are found on Panel L. If a stirrer overloads (trips-out) then it must be reset manually. The RLC will detect the trip and the probe will skip measuring that particular AZ until the problem is fixed. This condition is one of a range of abnormal operating (MSA status) conditions which may be encountered.

The RLC also monitors the status of the air pressure and in the event that the air pressure fails or fluctuates significantly (to below 500 kPa) the MEP will be automatically lifted from the slurry and a warning will be displayed on WinISA to inform the operators that there is a problem. An air failure message will also be displayed on the OI panel the MSA will revert to “manual mode”.

This is a self recovering error. Assuming the MSA was previously operating in “AutoMode”, when the air pressure is subsequently restored the next *move* command from WinISA will resume normal operation.

The probe window status is also monitored by the RLC and reported as either “Window OK” or Window Rupture” at the OI panel. Whilst operating in “AutoMode” a “Window Rupture” alarm message will also be displayed at the computer if a window rupture is detected. If a window rupture is detected the probe will be immediately raised from the slurry and control will revert to “manual mode”. The MSA will not resume operation until such time as the problem is fixed.

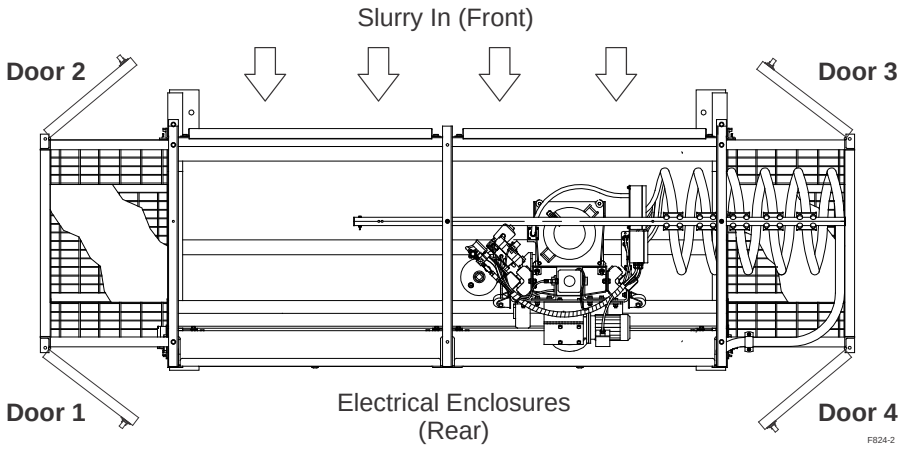


Figure 7-3. Plan view of MSA identifying access doors by number

Multiple safety guards and four electrically interlocked access doors are intended to prevent injury from moving parts. When the any access door is opened, the probe will freeze and all stirrers and samplers will stop. The MSA reverts to “manual mode” and will not return into “AutoMode (operational)” until the door or doors is/are closed. When a door is opened, the stirrers can continue working to prevent the analysis tanks from sanding up by pressing the “STIRRER OVERRIDE” button. When door 1 is open a message **Gd Open** will be displayed on the OI panel status display.

Figure 7-4. A door interlock and the Stirrer Override switch

Radiation Shielding

The MEP which has one, two or three radioisotope capsules inside, emits radiation in the forward direction (only), through the X-ray window and only if it is uncovered (unshielded). Under normal operation (immersed in the analysis tank) the slurry and tank walls act as a shield, intercepting all X-radiation from the probe. While the probe is moving between tanks shielding is provided by strategically placed metal panels and sampler covers. At other times a “standard biscuit” may clipped in place to take standard countrates and this biscuit actually acts as a satisfactory shield. Further details on radiation and its hazards are provided under Radiation Safety in Chapter 1.

Environmental Protection

By its nature most of the mechanical parts of the analyzer system have to operate under the normally arduous environmental conditions that prevail in a mineral processing plant. The Thermo Scientific design minimises the number of moving parts thus exposed and specifies large safety margins and wear lifetimes on those that are. Electrical and electronic control equipment is environmentally protected to AS/NZS 60529-2004 class IP65 or better. See Chapter 3 for Specification of Materials.

Non Emergency Stopping

The Thermo Scientific MSA is an automatic machine that should not be routinely stopped and started. It will run and look after itself for long periods. The most obvious way to stop an MSA as one might for a plant shutdown is to switch off the electrical power at the main switch/isolator or elsewhere. This makes sense when the whole plant shuts down, but if slurry continues to flow through the MSA tanks it is likely to settle and produce a hard deposit that will take some effort to clean out later. The preferred option is to PARK the MEP, leaving all

the stirrers running (or just those that could potentially sand up). There are other ways to do it – e.g. from the OI or WinISA but the PARK button is undoubtedly the easiest. The samplers will continue to operate in Shift mode if that's how they were running before. Otherwise some or all of them can be switched OFF at the normal SAMPLER switch.

Take Care: Do not PARK the MEP immersed in slurry or water for an extended period in case the window fails. ▲

Restarting

If the power-off method was used, on powering-up the MSA, provided the AutoStrt feature is turned on, the MSA will first execute a "Position Test". This is a form of POST (Power-On Self-Test) procedure which confirms that the MSA position sensing components (proximity sensors), probe movement, motor status, etc., is working. If a failure is detected an appropriate error message (see Table 9-1) will be displayed on the OI panel status line and the MSA will drop into the Offline (manual) mode.

If it was just parked, the yellow PARK button will still be illuminated. Make sure to remove any X-ray shield or "standard" that may have been put on the MEP and generally check there is no obstructions to its movement. Then release the PARK button. If WinISA is running it will detect the MSA coming back on line within 15 minutes and resume the normal analysis cycle. Remember to switch back on any stirrers or samples that have been rested during the shutdown.

What if it doesn't restart?

If someone has operate the E-Stop or opened a guard door whilst the MSA was sitting parked, even if they subsequently reset the E-Stop button and closed all doors, the MSA will not resume operation immediately when UNPARKED. Instead you should see the green (RE)START lamp (Figure 7-1) blinking away. If so, press it. If it is not blinking check the OI for error messages.

MSA Status

On power-up the OI panel will display the status of various components of the MSA unit which are under the control of the RLC (e.g. stirrers, probe, air, limit and proximity switches, etc.). The RLC will also detect any such component failure or abnormality during normal operation and report it to WinISA as well as display it in the "status" message line on the OI panel.

If the MSA does not attempt to go into a "Position Test" when powered up then the RLC may have lost its setup configuration, in which case you will need to enter the highest security level password and follow the following steps.

To Re-establish RLC Setup Configuration

1. Re-enter the RLC Zone Mask **<ZoneMask>** for your particular MSA (this is provided on installation by Thermo Fisher or it can be calculated from scratch by studying Figure 9-1).

2. In the same way you will also need to enter the defining bit pattern (in octal) for the samplers by selecting the menu option **<SMPMask>**.

3. Re-enter the *available* zones. This will be all or a subset of the Zone Mask you put in at 1. Above. Select **<ZneAvail>** and enter the octal number defining only those tanks you want the probe to visit until further notice.

4. Check the *Service Bay* has been correctly set, usually this is the last zone. If you prefer a different zone, enter it here.

5. If you want the MSA to resume normal operation automatically after a power failure, check now that **<AutoStart>** has been set to **Yes**.

6. Select **<Automode>**. The MSA should now perform a *Position Test* and resume operation. If not, switch the MSA power off briefly then on again. If a "Position Test" is not executed this time, check the OI display for error messages. You might see a that information is being down-loaded. This means the RLC is obtaining a fresh copy of its *Application* from the WinISA computer. This happens automatically if the App is corrupted but of course it won't if the WinISA computer is down or the data connection has failed. In this case the RLC will try indefinitely to obtain the Application code it requires. Check WinISA and the network connection and resolve any problem there.

Sampler Control

A multi-purpose switch is provided for each Metallurgical Sampler fitted on the MSA. These switches are located near the respective sampler itself (see Figure 7-7) and act as ON/OFF AUTO/MANUAL and ISOLATOR.

Power Failure

On a power failure, the MSA probe will be raised from the analysis tank that it was measuring at the time of failure.

On resumption of power, the MSA unit will resume operation according to the sequence setup in WinISA and provided the **<AutoStrt>** option at the OI panel has been set to "yes". If this option was set to "no" then the MSA unit will revert to *Manual* mode. It will not resume normal operation until it is reset to *AutoMode* at the OI panel and the next *move* command is received from WinISA.

If the WinISA computer fails, whether it be a power failure or shutdown of the server software, the MSA itself will pause with the probe in its current position (usually down in the last zone measured).

The MSA will remain in *Auto* indefinitely, awaiting further instruction. The MSA will only continue automatic (normal) operation upon resumption of the computer power and WinISA.

The Panel Layouts

The following drawings, Figure 7-5 and Figure 7-6 show the arrangement of the switchgear and other parts on the two control panels. These drawings include "reference designators" that will help locate them on the schematic diagrams of Appendix A. These panels have been substantially improved in the MSA-330 in as much as LV and ELV are now fully segregated in the wiring ducts and extra covering is provided to reduce risk of electric shock or arc flash. Apart from the 115V AC outlet, there is no hazardous voltage present inside Panel M.

Figure 7-5. Controller Arrangement – Enclosure L

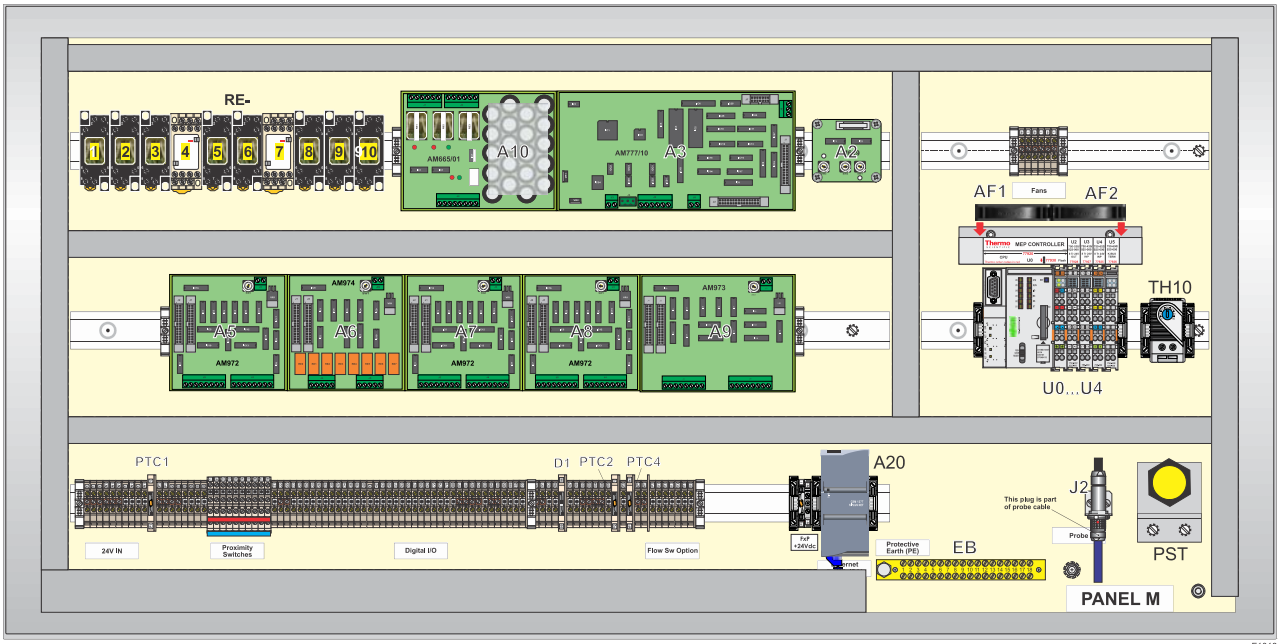


Figure 7-6. Controller Arrangement – Enclosure M

Caution Before any power is applied make sure hoist, stirrer motors and samplers are safe to operate freely. ▲

Take Care From this point you will be working on "live" equipment. Although all live parts are finger proof to IP20 as defined in AS/NZS 60529-2004 or your local supply authority or site rules may require that the following work is conducted by a suitable licensed person. ▲

Inside the Enclosures

The door can be opened by rotating the MAINS ISOLATOR switch to the OFF position and by using the door key provided. There are no exposed terminals inside which can be touched by human fingers. All the internal components comply with AS/NZS 60529-2004 IP20 however ***take care*** with tools such as a screwdrivers and meter probes on live terminals.

Warning The incoming mains terminal "L1", "L2", "L3" remain live with the mains isolator in the OFF position as do the top terminals of the isolator itself. ▲

Note Depending on local regulations, access to the inside of enclosure Panel L may be restricted to licensed electrical workers. ▲

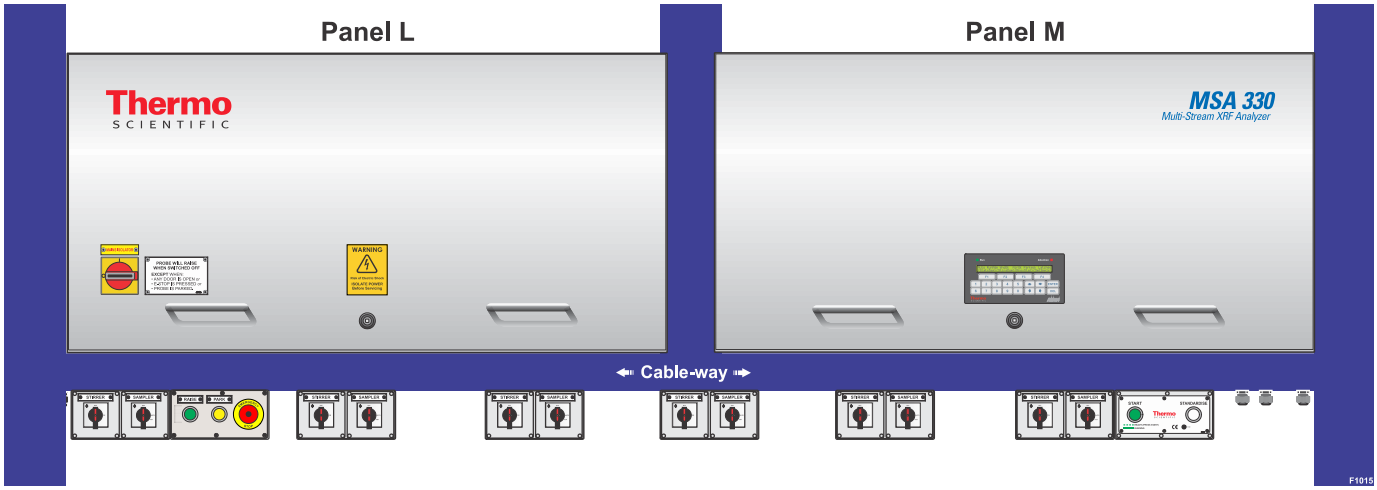


Figure 7-7. Front Panel Controls

Basic Operation

Once the electrical and mechanical installation of system is finished, then one should do a basic function test of the system and check the operation of all the components.

The MEP

The MSA utilises a Thermo Scientific Multi-Element Probe (MEP) for measuring up to twelve (12) streams on a time-sharing basis. There is a separate analysis tank for each stream into which the MEP can be lowered for a measurement. Refer to Operation of the MEP later in this chapter.

Probe Washing

A probe water spray is built-in to wash the probe between measurements so that stream cross-contamination doesn't occur. In *Manual* mode the water spray can be activated by selecting the OI menu option, **PrbSpray**. It must always be on during normal *AutoMode* operation.

Probe Movement

The detail work of moving the probe to a required tank is done by the RLC. The distant WinISA computer decides when and where to send it. WinISA is set-up by a user who will enter the stream measurement time and sequence (order in which the streams are visited). This in turn will determine the effective time lag that assays are reported behind actual values. Provided the MSA is in *AutoMode*, movement of the probe is in response to an AIN *move* command received from WinISA. If the MSA is in *Manual mode* then movement of the probe can only be done by manually selecting appropriate menu options from the Operator Interface (OI) panel. The MSA unit will only resume its configured movement pattern when set to *AutoMode*.

AutoMode

In this "remote control" mode, the probe will move in response to instructions from WinISA. i.e., WinISA is configured with the measurement time (in integral seconds) for each stream and the sequence in which the streams are to be analysed. The MSA software is configured during commissioning of the MSA on-site. The *AutoMode* of operation is selectable from the OI panel on the MSA unit. For safety reasons, switching into *AutoMode* from manual at the WinISA computer is disallowed.

Manual Mode

See Manual Modes on page 7-2.

Park Probe

The PARK feature is mainly for the convenience of those who must periodically add liquid nitrogen to the MEP. Providing the MEP and MSA is healthy and correctly configured and not already in an E-Stop or Guard Open safe state, pressing the PARK button will immediately interrupt whatever else it is doing and put the probe down in the most convenient spot for filling. This is usually the closest position to door 1 regardless of whether there is a tank there or not.

The PARK feature is also used when maintenance on the probe is required. This may include testing or changing a window, source etc. In these cases it may be preferable to have the probe in a raised position in which case one can use the green RAISE button as described under the heading Raise Probe, below.

Whenever the probe is parked, the MSA is in *manual mode* and therefore will not move under instruction from WinISA until such time as the PARK button is released.

Raise Probe

A green RAISE button is provided to allow the operator to raise the probe from the slurry after parking. In this position the probe can washed off and maintenance performed, including changing the window assembly. Note that this button is only active when the probe is in the PARK position. The value of this feature mainly applies when the park position is also a functioning AZ. If the intent is to replace the probe window or otherwise service the bottom part of an MEP, sending it to the PARK position normally[2] puts it ***down*** (submerged) in the service position. This may not be the most convenient or accessible position, in which case one should press the RAISE button. It must be held pressed for a few seconds to take the probe fully up. If only a partial lift is preferred, just jog it up with a brief press. The button illuminates when the probe reaches the top of its travel.

[2] If the window rupture state is active, i.e. moisture has been detected inside the MEP or if the window assembly has been removed, it will not go down. Instead it will be latched in the up position.

Analysis Tanks

Every stream presented to the MSA is directed through its own analysis tank (zone). Standard 300 mm tanks are designed to handle up to 15 m^3/hr of slurry either as a full-flow stream or a sub-sampled stream. Where there is excessive frothing such as is the case with concentrate streams a reduced flow should be considered. It is important that the slurry flow-rates are maintained within reasonable limits throughout the operating life of the MSA. Significant changes in the slurry presentation to the probe may result in the calibrations becoming unreliable, thus providing incorrect in-stream assays. It is particularly important that any primary (and secondary) sampling equipment used to provide reduced flows to the analysis tanks be regularly maintained.

A stirrer (agitator) is provided for every AZ. They each have an independent on/off isolator switch (see Figure 7-7). It is important, whilst slurry is flowing, that these stirrers are kept operating otherwise the analysis tank may "sand up". A failed or switched off stirrer will generally be detected by the RLC. This will register an error and as a result the probe will skip (not visit) that AZ until the problem is fixed.

A water spray is mounted above each tank of the MSA unit. These are manually set by a needle valve (one per spray) located on the rear of the MSA frame (see Figure 5-14). A main water isolation valve is also located here. This will shut off all water supply to the MSA unit. The purpose of tank water spray is to break down excessive froth, particularly in concentrate streams. It is important that a water spray is kept operational if that analysis tank's spray was running during calibration of that stream.

Metallurgical Samplers

Metallurgical cross-cut samplers are fitted to the outlet end of every analysis tank (see Figure 5-1). They have three distinct modes of control, viz. Shift Mode, Calibration Mode, and Manual Mode. As the name suggests *Shift Mode* performs stand-alone automatic cutting at a pre-determined frequency. Each "cut" diverts a small volume of slurry (i.e. a "sample") into a bucket. Most customers will collect the bucket at a predetermined time of day or a certain stage (e.g. the end) of the working shift. The *Shift Mode* of operation is totally unrelated and independent of the MSA's analysing role - i.e., shift sampling can proceed even if the probe is broken or offline. However if the sampler is needed to perform a "calibration" series of cuts, this will take priority over shift mode. A calibration sample ties up the sampler for only 5 to 20 minutes so if the "shift" bucket is put aside briefly for that period and replaced there is usually no significant impact on the average assay obtained.

Note The SAMPLER switch shown in Figure 7-8 is actually a true isolator, i.e. it breaks both power conductors to the sampler motor in the OFF position. Consequently it ***must*** be in the **AUTO** position for any sampling including Manual Mode ▲

The user should also refer to the Using the Operator Interface Panel in Chapter 7 .

Manual Mode

This is effectively an off or idle mode where no automatic sampling will occur. There is a menu item on the OI called **Take Cut** that will trigger a single cut on demand; however the easier way is to use the SAMPLER switch found under the blue cableway and near the sampler involved.

This feature is software independent and intended to allow someone to put any number of cuts (or extra cuts) into the bucket for whatever reason. The user has to only flick (rotate briefly) the SAMPLER switch to CUT (see Figure 7-8) to actually take a sample cut. In this way one can capture a spot sample or top up a partially filled bucket, for example. This latter situation may be an example of tampering or intentionally biasing the sample and this possibility should be considered by management and dealt with if deemed necessary. The switch's CUT option can be disabled by a simple wiring change.

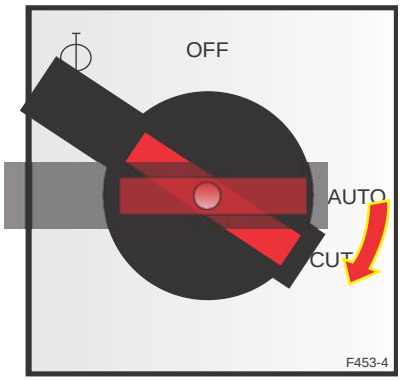


Figure 7-8. Taking a Manual Sample Cut using the sampler switch

Calibration Mode

Calibration mode is not one that is generally used by a plant operator in the course of his/her daily work. Its sole purpose is to ensure and guarantee that a slurry sample delivered into a bucket is exactly synchronised with the corresponding count rate record so that when the laboratory assay (for that particular bucket load) is reported, the correct and unambiguous set of numbers (count rates) is/are associated with the assay numbers for the purpose of correlation viz., calculation of the cross-mapping function: counts-to-percent element. A calibration sample is one that is deliberately collected over a short time (before the grade can vary too much) but a long enough period to capture a statistically valid number of counts. Typically this is about five minutes (300 sec) during which time the sampler takes (say) 25 equally spaced (in time) cuts. These values (300 and 25 in this example) are entered into WinISA and stored on the server for future use.

Shift Mode(s)

There are two sub-modes of shift samples; one is the "standard shift" mode which provides the operator with a composite shift sample that is collected over a plant shift with sample cuts being taken at ***regular*** time intervals pre-set by selecting Smp-Time at the OI (this interval needs only to be set once for each stream).

“Random Shift” mode provides shift samples composed of samples which are cut ***randomly*** within a pre-set time interval. The user is prompted to pre-set a minimum time required between such samples so as to avoid the possibility of two samples being taken very close together.

The choice between standard (evenly spaced) sampling and random ones is made when one changes into Shift Mode from any other mode.

Who does What?

Whereas the RLC does the Shift Mode timing (and remembers indefinitely the chosen cut frequency), it is the EPC that actually times the Calibration Mode cutting. Consequently Shift parameters have to be set into the RLC via the OI, and Calibration ones are transferred to the EPC but entered into, and remembered by, WinISA.

Operation of the MEP

The Thermo Scientific MEP uses low-energy radioisotope X-ray source(s) and a Si(Li) solid-state X-ray detector whose high selectivity and sensitivity enables the accurate and repeatable measurement of very low concentrations of elements, such as those encountered in copper tailings streams. The MEP is capable of measuring elements down to calcium in the table of atomic elements and can measure up to twenty or more elements and slurry density simultaneously.

The MEP uses the radioisotope source(s) to excite fluorescent X-rays from elements in the slurry or solution (details of the radioisotope(s) used in your probe are stamped on the radiation label on the probe). Each element in the sample emits fluorescent X-rays of an energy and intensity which is characteristic of that element and its concentration. The fluorescent and back-scattered X-rays from the mineral particles are converted in the detector to minute electrical pulses that are amplified and classified according to their associated elements. The voltage of the electrical pulse is proportional to the energy of the incident X-ray. The number of X-rays is proportional to the elemental concentrations in slurry. Scattered X-rays (those of the same or nearly same energy as the source) are related to the average slurry percent solids (density).

Note Radioisotope sources used in Thermo Scientific analyzers have a recommended working life (RWL) between 5 and 15 years. This does not necessarily preclude the use of a source beyond its RWL. Beyond that date the local radiation authority may demand that a wipe test is conducted on the source to check its package integrity and it can continue to be used for its application. However, some local regulatory

bodies may require disposal of a source after it has reached its RWL. Check with your Radiation Safety Officer (RSO) or local radiation authority. ▲

MSA Controlling Electronics

There are two controller enclosures included in a basic[3] MSA. One of these (Panel M, Figure 7-6) houses the RLC which is a Thermo Scientific proprietry logic controller similar to a PLC. The RLC is linked to the Operator Interface (OI) panel mounted on the lid of Panel M. Users can configure and control the MSA through this OI to some extent. Panel M also houses a the EPC which is a computer based controller capable of larger mathematical tasks and programmed in Visual C on Linux. The EPC also acts the communication gateway for the RLC so that both can deal with their respective commands from WinISA.

The RLC and the EPC share the task of controlling the MSA. The RLC is responsible for all motion control such as probe positioning, stirrer operation and starting and checking the Metallurgical Samplers.

Some of the safety-related functions are implemented in a bank of conventional relays on *Panel M*. Working together with discrete logic components, these relays offer verifiable safety functionality that does not critically depend on microcontroller software. Indeed it incorporates a second level “watchdog” timer that will withdraw the MEP from slurry in the event of critical software (firmware) malfunction.

Under normal operation the MSA is run in "AutoMode" which means the probe movement and stream measurement time and sequence are determined by the user defined configuration in the computer software. "Manual mode" can only be selected from the OI panel. The MSA executable module (Application code) is down-loaded to the RLC from WinISA over Ethernet on initial start-up. Up-dates of this module can be down-loaded remotely to the MSA from the Thermo Fisher Scientific support office.

The EPC essentially drives and supports the MEP. The fast nucleonic signal processing electronics buried inside the MEP continuously interacts with the EPC to produce sensible numbers that can be passed on to WinISA for tabulation and analysis.

The incoming mains power enters Panel L (Figure 7-5) which has a main isolator/overcurrent breaker as well as motor protection circuit breakers (MPCBs) for six stirrers. There are also other breakers associated with the multi-tapped control transformer and a high quality

[3] A basic MSA consists of a single “frame” capable of holding up to six 300 mm wide tanks. This frame also supports two control enclosures and their interconnecting cableway or duct. Extended MSAs have an extra three or six tank frame and support a third control enclosure for the extra switch-gear required.

24 Vdc, 5 amp power supply. The control circuit is entirely based on 24 Volts DC.

Panel L also houses six proprietry sampler cards (PCBAs) and a variable speed motor drive (VSD) for the horizontal drive motor. The VSD is Thermo Fisher factory set as shown in Table 7-1. All other parameter settings are default values defined by Allen Bradley and can be reloaded back to those values with a short keystroke sequence.

Table 7-1. Variable Speed Drive Parameter Settings

Allen-Bradley AC Drive Parameter Settings – Model Powerflex 4M			
Parameter Number	**Parameter Name**	**Default Value**	**Set Value**
P101	Motor Volts[4]	460	400
P102	Motor Hertz	60	50
P103	Motor Amps	2.6	1.1
P105	Max Frequency	60	50
P106	Start Mode (2 wire)	0	2
P107	Stop Mode (Coast)	0	5
P108	Preset Frequency Mode	0	4
P109	Acceleration Time 1	10.0	1.2
P110	Deacceleration Time 1	10.0	0.4
A401	Acceleration Time 2	20	1.2
A402	Deacceleration Time 2	20	0.4
A411	Speed 1 (Hz)	5	30.0
A412	Speed 2 (Hz)	10	40.0
A413	Speed 3 (Hz)	20	50.0
A436	Compensation	1	0
A437	Slip Frequency (Hz)	2.0	0
A451	Restart Tries	0	2
A452	Delay between retries	0	10.0
A458	Program Lock	0	1

Starting from Scratch

There are many more parameters in this VSD than listed above. The remainder can and should all be left at the Allen Bradley defaults. If there is any doubt that one or more of those parameters have been changed and appear to be affecting the drive, they can all be reset using parameter P112. Make sure the VSD is powered up but not driving the motor by (say) opening access door 1. Then press STIRRER OVERRIDE if you wish to keep stirrers running (they do not use the VSD).

Navigate to P112 and set it to “1”. This will reset every parameter. It will also reset itelf to “0”. This will result in fault message F48 being displayed. Cycle the power to clear this fault. Then proceed to enter all the values listed in Table 7-1, finishing with A458 to lock them in. The MSA should now operate normally.

[4] This value is always 400 regardless of the incoming supply voltage. Similarly all other VSD parameters are independent of mains voltage or frequency

Using the Operator Interface Panel

The Operator Interface (OI) panel, located on the lid of Panel M, has a membrane keypad and a LCD display of two lines of 40 characters. It also has *Run* and *Attention* LED indicators. The OI enables user interaction with the MSA unit via the RLC. In both "automatic" and "manual" modes of operation the user has access to all the OI functions available with their pass code level of access[5] which must be entered at the menu item **MenuMode**. The AM894 Operator Interface is shown below.

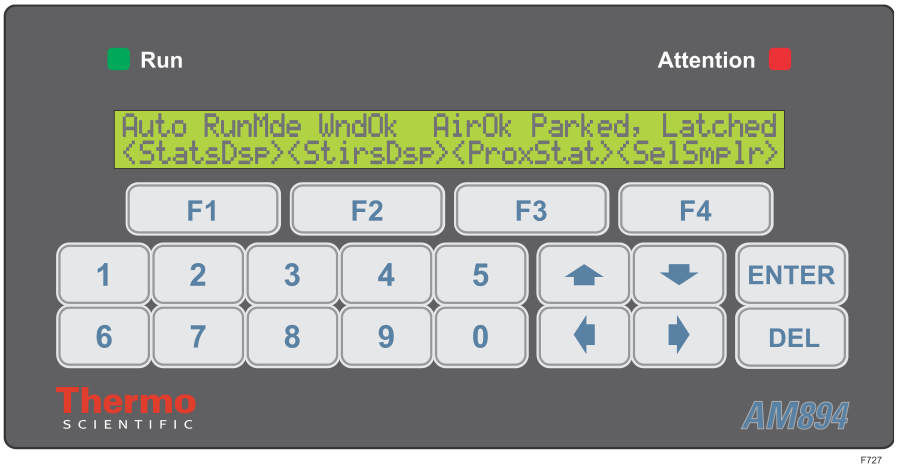


Figure 7-9. Operator Interface Panel

Display Item Types

Menu items can be of two types, **Display Only** or **Enter Data**. Both types are selected via the function keys. Selecting a **Display Only** item will display a message (usually a status report) on the top line. Selecting an **Enter Data** item will display a message which will generally contain the current value of a data item, the allowable limits and a request to enter a new value.

Using the keys

New values to be entered are generally numeric. As the numeric keys, **<0>** through **<9>**, are pressed, it is evaluated by the RLC firmware and if valid, displayed. If it is greater than the upper limit, the key is ignored. In some cases, numerated values are entered by using the arrow keys. In these cases, the user is informed of this option.

<DEL> This key will delete the least significant digit of the current value. During the **Enter Data** sequence, pressing the **<DEL>** with no data entered key will abort the sequence and return to the menu at any time. The direction keys are usually ignored in this mode.

<ENTER> When the desired numeral or arrow has been typed, pressing **<ENTER>** will have this value accepted and return to the main menu.

---

[5] There are three levels of passcodes for the RLC Operator Interface. These can be found elsewhere in this document or obtained from any Thermo Scientific MSA customer support engineer.

<F1>, <F2>, <F3> and **<F4>** are Function Keys that are re-assigned to perform different functions at each level.

Start-Up Menu. Upon start-up, the OI panel will display a status line at the top and a selection of four menu options directly above the function keys (**<F1> <F2> <F3> <F4>**).

To select a menu option press the **<F..>** key immediately below the menu item you wish to access. Except for a few keys that act directly, the display will change to a question or detail with possibly more choices to drill even deeper.

The **<Up>** and **<Down>** keys are used to move between the various menu levels.

The Operator Interface Menus

There are seven (7) levels of OI menu which are entered using the Function Keys. They appear on the LCD immediately above **<F1>, <F2>, <F3>,** and **<F4>** as listed in Table 7-2. To navigate up and down the seven levels use the **<Up>** and **<Down>** keys.

Table 7-2. The changing role of the Function Keys

Level	<F1>	<F2>	<F3>	<F4>
1	<StatsDsp>	<StirsDsp>	<ProxStat>	<SelSmplr>
2	<DebugDsp>	<ZonesDsp>	< >	<MenuMode>
3	<SelSmplr>	<Smp-Mode>	<Smp-Time>	<Take Cut>
4	<AutoMode>	<Sel Zone>	<MovePrbe>	< >
5	<PrbSpray>	<ZneAvail>	<ServcBay>	<AutoStrt>
6	<Open Rly>	<CloseRly>	<ForceRly>	<Free Rly>
7	<ResetRLC>	<ZoneMask>	<Smp Mask>	<Rst Data>

Note Menu levels three (3) to seven (7) are access-restricted, and so require a password to be entered upon selecting <MenuMode> to proceed further. ▲

Menu Level 1

At Menu Level 1 the F-keys will be assigned the following labels:

<StatsDsp><StirsDsp><ProxStat><SelSmplr>

The function of each is as now as follows:

<StatsDsp> (F1)

will display the main status display on the top line. This display will typically appear as:
Auto RunMde WndOK AirOK Rdy123456789ABC

The fields are as follows:

Man/Auto for manual or automatic operating mode.

GdOpen/RunMde/EMStop to indicate whether the MSA is in Run Mode or if the

"Emergency Stop" button has been pressed, or if one or more of the the interlocked guard doors are open. The **EMStop** message has preference although one or more access doors may be open as well.

WndRpt/WndOK indicates the status of the probe window rupture.

AirFl/AirOK indicates the air pressure level.

Before a self test has been performed, the next field (i.e. the rest of the line) will show **PositionTestReq** indicating that a required confirmation test of all proximity switches has not yet been done. This is mandatory after every power up or RLC reset. The MSA will not run in AutoMode until it has completed. Once it has begun the OI will display **PositionTesting**. Once a self test has been performed the next field shows which zones are ready (i.e. Those which are enabled by the ZoneMask and have not positioning error and the corresponding stirrer is going).

If an error occurs, it is displayed in this field. Typical messages are : **ErrRaisingPrb x**, **StuckAtLstZne x** and others. Here "x" is the zone at which the error occurred. x is one of the following characters **R123456789ABCFP** where **R**=Reverse Limit Switch, **F**=Forward Limit Switch, **P**=Park limit switch, **A**=zone10, **B**=zone11 and **C**=zone12. Refer to Table 9-1for an explanation of these messages.

When the **PARK** button has been pressed the message **Parking** followed by **Parked, Latched** will be displayed.

When none of the above messages are occupying the end of the text line, it wjill display which zones are ready **Rdy**, numbered **1** to **C**. Any zones that aren't ready will be indicated by a blank. A zone must be defined in the zone mask, see **<ZoneMask>** and available, see **<ZneAvail>** before it can be shown ready for analysis. Turning off a stirrer will render that zone 'not ready'.

<StirsDsp> (F2)

is used to display which stirrers are running and which units are in overload condition. A typical display might be:

```
Stirrer Run 12345__89ABC O/L_____67_____
```

The presence of the "**O/L**" label does not mean there is an overloaded stirrer unless the stirrer number is also given.

<ProxStat> (F3)

is used to display the state the proximity sensors are reading. A typical display is:

```
Zone R12*4567__ABCFPuD Dwn Fwd Stop 2340
```

The fields are as follows:

Zone. An ***** in this field, indicates that the probe is at *that* zone (i.e., in this example it is in or above zone 3). The two underscores (**__**) indicate that zone 8 & 9 have not be found or configured. The lower case "**u**" indicates that the probe is not up (a "**U**" would indicate this). The "**D**" implies the probe is down. If the probe is not positioned at a zone, either an "**r**" or '**f**" indicating reverse or forward carriage drive motor will appear between "**Zone**" and "**R123...**" (eg. **ZonerR12*...** implies the probe is to the reverse of position 3).

If the probe carriage-drive motor is in overload condition (and hence the probe cannot move) the previous display will be replaced with the following message: **Probe MotorOverload** .

Dwn This second field reflects the vertical position of the probe. It is one of **Hld**, **Up**, **Dwn**, **u?d**' (i.e. **Hld** indicates "Probe Held" (e.g. when the **RAISE** button is pressed) and **u?d** indicates an error).

Fwd The third field reflects the horizontal movement of the probe. It is one of **Stn**, **Fwd**, **Rev**, or **r?f**' to indicate (repectively) *stationery*, *moving forward*, *reversing* and *action not known* (which implies an error).

Stop The fourth field reflects the current probe motor speed. It is one of **Stop**, **Slow**, **Fast** or **Trbo** to indicate one of *stopped, slow, fast* or *turbo*. In the last group of four characters, the state of the probe wash spray is reflected by either an **S** for *spray*

(indicating the spray is on) or the position of the probe, followed by the last zone the probe was at, the current position and the next position. An internal state (for debug) is displayed in the last position.

<SelSmplr> (F4)

Displays the current state of a sampler. Each time it is pressed, the next valid sampler state is displayed. The display is described later.

Menu Level 2

No passcode required. Here the F-keys will be assigned as:

<DebugDsp><ZonesDsp>< ><MenuMode>

The function of each is as now as follows:

<DebugDsp> (F1)

displays a bit map of the actual low level RLC input/output states. They are for factory use only. The first field displays the version number of the application code (eg M123 implies MSA code, version 1.23).

<ZonesDsp> (F2)

will display the available zones are set by the user (see later). A typical display is as:
ZneAvl 1234_S789__C AutoStart

The fields are as follows:

ZneAvl is a list of which streams are currently active. In the above example, zones 5,10 and 11 have been declared (by the user) not to be active.

The '**S**' indicates that zone 6 has been declared to be the service zone and it has been confirmed as having a working prox during a Position Test. A lower case '**s**' would indicate that the zone has been entered as being the service bay (see **<SrvcBay>** but it has not been confirmed by position testing. Upon a PARK request (due to the user pressing the yellow **PARK** button), the probe will go to that zone.

NoAutoStart/AutoStart indicates whether auto-start on power up is required.

<MenuMode> (F4)

is used to access more secure levels of the menu. The question, **Enter "Menu Mode" Pass Code**, is asked. The menu has three levels of access. By default the PassCodes are 416, 417 and 418. These are called level 1, 2 and 3 passcodes respectively. At level 1, only first three menu levels can be accessed. The Level 2 passcode gives acces to five menu levels. Entering the level 3 passcode makes all seven levels available.

Caution: The Pass Codes, particularly the higher level ones, should not should not be widely disseminated or posted on the MSA for all to see. Doing so may result in unwanted tampering with the RLC settings. ▲

Menu Level 3

At Menu Level 3 the F-keys will be labelled:

<SelSmplr><Smp-Mode><Smp-Time><Take Cut>

The function of each is as now as follows:

<SelSmplr> (F1)

Displays a sampler status and is used to select a metallurgical sampler to operate on. As

it is pressed the sampler number in the top line, which reads like **Sampler 1 Mode Off Period 0 mins** is incremented for each valid sampler. For each sampler installed the mode (**Off**, **Manual**, **Calib** or **Shift**) is displayed.

<Smp-Mode> (F2)

Used to change the mode of a sampler. The question asked is **Smp Mode (v=Off ^=Man <=Cal >=Shft)**. If Shift mode is selected the question **Take Random Samples (^=Yes,v=No)** is asked. If random cuts are required, a further question **Min. time between samples (minutes)** is asked.

After a mode change is made, a request to the change the bucket is made. Its form is **Change Bucket & Continue (^=Yes,v=No)**.

For calibration mode, the following messages are displayed depending on the status:

Calib Sample Failed
Waiting Bucket Change
Ready to take Samples
Taking Sample Cuts
Calib Sample Taken

They reflect the status of the calibration sample for that zone.

<Smp-Time> (F3)

Used to change the sampler cut time when in shift mode. The question asked is **Sampler Period (Minutes)** e.g. if you have an 8 hour shift then you may want to take a cut every 30 mins, then 16 sample cuts will be taken over the shift period.

<Take Cut> (F4)

Used to take a cut with the currently selected sampler

Note: The menu item **<TakeCut>** does not need to be used to take a manual cut, instead one can use the Sampler Switch (see Figure 7-8). Simply rotate briefly to the CUT position. The Sampler Switch overrides the settings in the Operator Interface menus. To isolate the sampler, simply switch it to OFF, where it can be "locked out" for safety reasons.The Sampler Switch must in AUTO for both shift and calibration sampling. ▲

Menu Level 4

A level 1 passcode is required. Here the F-keys will be assigned the following labels:

<AutoMode><Sel Zone><MovePrbe>< >

The function of each is as now as follows:

<AutoMode> (F1)

is used to put the system into automatic operating mode (i.e. under remote computer software control, e.g. from WinISA). The MSA will move to streams automatically. The question **Select Mode (^=Automatic,v=Manual)** is asked.

<Sel Zone> (F2)

Is used to send the probe to a particular zone. The question asked is **Enter Stream to Select (1,2,3,. . . .)** .

<MovePrbe> (F3)

Is used to move the probe horizontally & vertically. When selected the following message is displayed **<=Rev >=Fwd ^=Up v=Down Del=Stop**. Pressing the direction keys will send the probe in the direction requested. The probe will NOT move horizontally if it is not clear of the zones. The **<ENTER>** key is used to exit this option. **<MoveProbe>** will only function when the MSA is in **ManualMode**.

Note: **<SelZone>** or **<MovePrbe>** can be done in either Auto or Manual mode, however in AutoMode your request can be overridden by the remote ISA computer at any time. ▲

Menu Level 5

A level 2 passcode is required. The F-keys will be assigned the following labels:

<PrbSpray><ZneAvail><ServcBay><AutoStrt>

The function of each is as now as follows:

<PrbSpray> (F1)

is used to operate the probe wash sprays. The question asked is **Probe Spray (^=Start,v=Stop)** The probe wash spray will remain on until an overriding request is made.

<ZneAvail> F2)

is used to select which zones are available for analysing. The question **Zone Numbers to change (1..12,0=All)** is asked, upon which the desired zone is entered. Then the new state is requested via the **Zone Status (^=Online v=Offline)** question.

<ServcBay> (F3)

is used to select which zone is to be used as a service bay when a park request is received. The question **Service Bay (1..12,0=ParkBay)** is asked

<AutoStrt> (F4)

is used to select the auto start on power on. The question asked is **Auto Start on PowerUp (^=Yes,v=No)**. If 'No' is selected the MSA will power up in manual mode. If 'Yes' is selected the MSA will power up in auto mode but only if it was in auto mode prior to the power failure and/or there were no problems that cause 'man' mode, such as window rupture.

Warning: The MSA will not automatically analyse the zones (streams) required unless it has been told that the zone is available using **<ZneAvail>**. ▲

Warning: The MSA will not automatically perform a position test on power up nor re-start analysing after a failure unless the **<AutoStrt>** option is set to **Yes**. ▲

Menu Level 6

A level 2 passcode is required. The F-keys will be assigned the following labels:

<Open Rly><CloseRly><ForceRly><Free Rly>

The function of each is as now as follows:

<Open Rly> (F1)

is used to open a particular relay. The question asked is **Relay to Open (10-17, 20-27, 30-37)**. The relay number is expressed via the number on a particular board. Some examples are, 10 implies relay 0 on module 1, 31 implies relay 1 on module 3, 48 implies all relays on module 4, 170 implies high order relay 0 on module 1 (ie. 17 mod 16), 330 implies low order relay 0 on module 1 on the second bus.

<CloseRly> F2)

is used to close a particular relay. The question asked is **Relay to Close (10-17, 20-27, 30-37)**.

<ForceRly> (F3)

is used to force a relay or input to a particular state. The first question asked is **Relay to Force (10-17, 20-27, 30-37)** followed by **Which way (v=Open, ^=Closed)**.

<Free Rly> (F4)

is used to free a relay from being forced. The question asked is **Relay to Release from being Forced?**

Menu Level 7

A level 3 passcode is required. The F-keys will be assigned the following labels:

<ResetRLC><ZoneMask><Smp Mask><Rst Data>

The function of each is as now as follows:

<ResetRLC> (F1)

will reset the RLC. The question asked is **Reset RLC? (^=Yes,v=No)**. If three resets occur without a power off, the application will be aborted and all setup parameters are erased. This menu option is normally only used during factory set-up and testing. If extra analysis tanks (zones) or metallurgical samplers are installed on-site then this menu option can be used.

<ZoneMask> (F2)

is used to select the number of analysis zones that are actually installed. The question asked is **Zones Built (octal)**. The top line will display the current setting. A typical message is
Zones 123456_____ Samplers 123456_____ which implies that zones and samplers 1 to 6 are installed. The new number must be entered as a base 8 number. Typical zone mask numbers are:

17==> Streams 1,2,3 & 4 are installed

7==> Streams 1,2 & 3 are installed

77==> Streams 1 to 6 are installed

7777==> Streams 1 to 12 are installed

37==> Stream 1,2,3,4 & 5 are installed (see example in Figure 9-1)

The RLC MUST perform a position test if a change is made, usually this would be initiated by cycling the MSA main power switch.

<SMP Mask> (F3)

is used to select the number of metallurgical samplers installed. The question asked is 'Samplers Installed (octal)'. The answers MUST be entered as a base 8 number (i.e. 17==> Samplers 1,2,3 & 4 are installed; 7==> Samplers 1,2 & 3 are installed). See example in Figure 9-1. The RLC must perform a position test; usually this would be initiated by cycling the MSA main power switch.

<RST Data> (F4)

is used to reset the RLC data base (eg. samplers installed). The question asked is 'Reset All Save Data RLC (^=Yes,v=No)'. This is currently only available for Unix ISA Software Systems.

Warning: The MSA will not operate if the zone mask has been wiped out of RLC memory. In this case re-enter the zone mask using this menu option **<ZoneMask>** at the OI panel. You will then need to tell the RLC which zones (streams) are actually available by selecting **<ZneAvail>** option at menu level 5. ▲

Warning: The metallurgical samplers will not operate if the sampler mask has been wiped out of RLC memory. In this case re-enter the sampler mask using this menu option **<SmpMask>** at the OI panel. ▲

Note: After re-entering RLC data, the MSA will need to be put back to "AutoMode" at menu level 4 and restarted by cycling the MSA main power switch so that it performs a new "PositionTest" otherwise it will stay in "ManualMode" and not re-start under computer control. ▲

The Service Position

During commissioning a *probe park* or *service* position would have been defined. In this way the MSA unit is configured so that when the **PARK** button is pressed the probe will immediately abandon whatever it was doing and move to the zone that is allocated as the service bay. To allocate a park zone (service bay) the operator must select the **<ServcBay>** menu option at Menu Level 5 of the OI panel then enter the zone number (e.g. "6").

Sampling System

To ensure that the MSA provides the best possible accuracy, it is very important that the probe measures a truly representative sample of the whole slurry stream and that most of the entrained air has been removed from the slurry. These conditions are satisfied by the specially designed tank called an Analysis Zone (AZ).

Slurry Effect

The analyzer probe 'sees' and measures a relatively large proportion of the slurry stream which is passing through the Analysis Zone and this ensures that the assays provided by the ISA system are representative of the whole slurry stream. The volume of slurry 'seen' by a probe depends on the volume that the probe 'sees' at any one time and the velocity of the slurry (or how quickly that volume of slurry is replaced).

The sample "seen" by the analysis probe is about 5mm deep (X-ray penetration) by 20 mm diameter. Although the proportion of the stream actually measured by the probe seems small in absolute terms, it is a much higher proportion of the total stream than is taken for manual

process control samples and it is a more representative sample because the slurry is homogeneously mixed in the specially designed Sampling System.

A stirrer is almost always required in any AZ to ensure that a well-mixed representative sample is presented to the probe. The MSA is supplied with stirrers in every AZ and their operation is controlled from the front panel of the MSA Controller.

Operation of the Metallurgical Samplers

The sampler head incorporates a DC motor, limit switches and a belt driven cutter among other things. It is controlled by an AM987 Sampler Reversing Module (one per stream). The SRM switches the DC power to the motor. This module is able to reverse the polarity of the DC feeding the motor and does it only when correct and safe to do so. Reversing the polarity reverses motor direction. Limit switches in the sampler head are combined with diodes so that they break only one direction of current flow. This philosophy results in a sampler head that needs only two wires (plus the safety earth wire) to connect up. Furthermore, the polarity of these two wires is optional, hence an installer may wire them either way. Traditional samplers need up to six wires, carefully connected in correct fashion.

The limit switches in the head not only remove power at the end of stoke, they also apply electrical braking to the motor. The AM987 is able to sense the break in current after which it removes the voltage entirely. Special techniques are used to eliminate arcing at contacts, a problem particularly associated with inductive DC loads.

One cut is defined as a *single pass of the cutter*, either left to right or right to left, but not both. A seven second timeout is applied to the cut stroke. If for example the sampler jams or stalls for any reason and this time expire, the Sampler will be taken off-line and a red fault LED on the corresponding AM987 will come on (see) and will have to be reset. A reset can be done in several ways including pressing E-Stop briefly, followed by a RESTART.

Three modes are available and these are selected by the Sampler Isolator switch shown below.

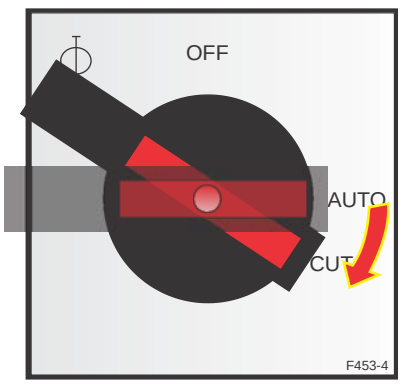


Figure 7-10. The combined Sampler Isolator and Control Switch

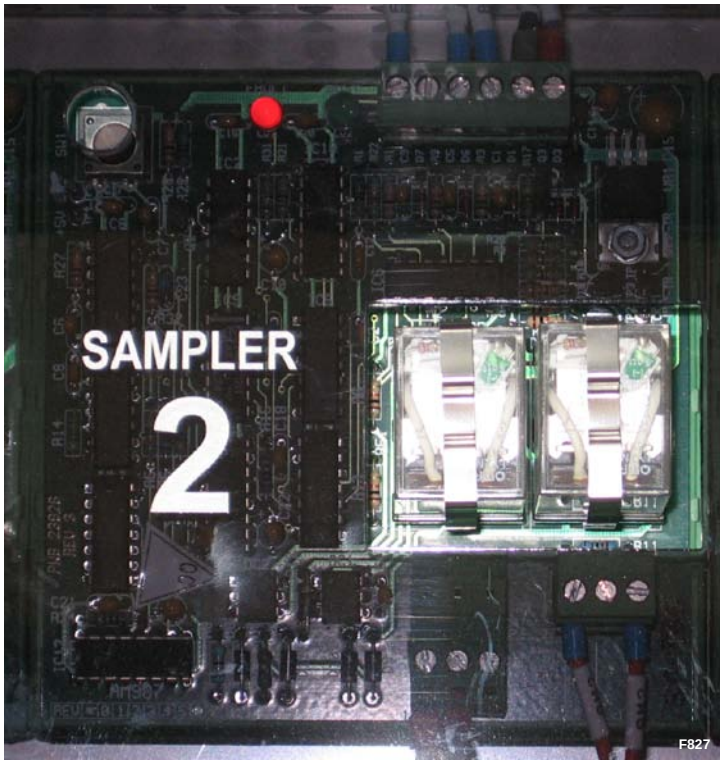


Figure 7-11. An AM987 Sampler Reversing Module showing a fault

In the MSA-330, the SRMs are behind a smokey grey perspex cover for enhanced electrical safety (see Figure 7-11). This cover has been marked with the associated sampler number above each SRM. Despite the darkened perspex, the two LEDs on each SRM are still quite visible when they come on. There is a green one that lights whenever the SRM is delivering power (typically 180 Vdc) to its Sampler. In Figure 7-11 you can see a red fault LED is on. This is because Sampler 2 has failed. The SRM will make no further attempts to drive the Sampler now. In order to reset the fault condition, one can insert a ball point pen or similar thin object in the hole just to the left and press the PCB mounted button. Or press and release the E-Stop.

Table 7-3. Modes of Operation of Metallurgical Sampler

Mode	Function
Calibration	Turn the Sampler Isolator switch to AUTO position. Sampler operates at regular intervals to take the required number of cuts over the defined calibration period. The duration of the calibration sample is determined via a setting in WinISA.
Shift	Turn the Sampler Isolator switch to AUTO position. Sampler takes cuts with specific interval between each CUT over a shift. The interval between cuts can be fixed or random as selected using the Operator Interface.
Manual	Allows the user to directly control the sampler using the **SAMPLER** switch by briefly rotating it to the CUT position.

Mode	Function
	One cut is made each time the switch is rotated to CUT position. There might be a slight delay if another sampler is cutting.

Figure 7-12. The Metallurgical Sampler used on MSA-330

Operation of the MEP

The MEP uses a low-energy radioisotope X-ray source and a Si(Li) solid-state X-ray detector whose high selectivity and sensitivity enables the measurement of very low concentrations of elements, such as those encountered in copper tailings streams. The probe is capable (in principle) of measuring all elements of atomic number greater than 19 (Potassium) and density simultaneously.

The MEP uses the radioisotope source to excite fluorescent X-rays from elements in a mineral slurry or solution (details of the radioisotope used in your probe are stamped on the radiation label on the probe). Each element in the sample emits fluorescent X-rays of an energy and intensity which is characteristic of that element and its concentration. The fluorescent and back-scattered X-rays from the solutions impinge on the detector to produce small electrical pulses that are amplified and transmitted to the Signal Processing electronics unit for processing. The voltage of the electrical pulse is proportional to the energy of the incident X-ray. The number of X-rays is proportional to the elemental concentrations in slurry. The scattered X-rays are used to provide measurements of the density.

Chapter 8 Maintenance

The Thermo Scientific MSA has been designed to minimise routine maintenance. All motor bearings are grease lubricated for life and thus are maintenance free. Air equipment, including cylinders and solenoid valves are lubricated for life and require no routine maintenance. The airline filters are fitted with automatic drains to release any water trapped in them.

To maintain the system in good working order, a *Preventative Maintenance Schedule* is offered herein. However, as plant conditions can vary considerably, this plan should be taken as a guide only. The commissioning report may contain additional maintenance recommendations. In addition, Thermo Fisher recommends recording all maintenance performed on analyzer system with the aim to develop a maintenance program to suit the site.

Preventive Maintenance Schedule

This section covers the daily, weekly, monthly, 3-monthly, 6-monthly, and 12-monthly maintenance requirements for the system.

Daily Maintenance

This is usually performed by plant operators; approx. duration is 5-10 minutes per analysis stream.

- Inspect the analysis tanks to ensure that they are functioning correctly and slurry is flowing freely (i.e., no sanding or blocking) and look for slurry flowing over the “baffle” in the tank.
- Check/unblock primary sampler/sample delivery lines if necessary. Report excessive slurry flow or surging.
- Check static cutters in primary sampler sections and clean if required.
- Check that stirrers are working correctly. If the stirrers appear to be under-agitating, check for wear/damage or trash material. This may entail draining the tank and checking the condition of the stirrer blades.
- Check water sprays are working correctly.
- Check that assay data is being displayed correctly on the WinISA or DCS screen(s). If not, then check for alarm/warning messages and investigate why. If a Window Rupture alarm is displayed then check that the probe is raised out of the slurry and replace the probe window as soon as is practically possible (refer Replacing the Probe Window later in this chapter).

Weekly Maintenance

Approximate duration for this, is 40 minutes per Thermo Scientific MSA.

- Take one or two calibration check samples per stream. These should be compared to the MSA readings at the same end time, and then added to the suites of calibration data.
- Check the operation of the froth depressant water spray where they are being used. Failure of any of the probe water sprays may cause cross-contamination or incorrect readings if it's a froth spray that has failed, clean or replace if necessary.
- Wash relevant parts of the MSA with a low pressure water hose to prevent slurry build-up. Particular attention should be made to cleaning moving parts, including the guide wheels on the moving carriage, metallurgical sampler cutter and nozzle, stirrer motor/gearbox, shaft and impellor.
- Check the cleanliness and condition of the probe window. Clean and replace as necessary (procedures are provided in Cleaning the Probe Window later in this chapter).
- Check the condition of the proximity sensors. Clean any prox that is covered heavily in slurry.
- Check led status beacon on the probe for cleanliness. Wash with warm water if particularly dirty

Monthly Maintenance

This is usually performed by plant maintenance personnel; approximate duration of each task is 5 – 10 minutes per MSA.

- Ensure the hoist air cylinder (ram) is operating correctly. Check the protective boot and replace as necessary.
- Check the operation of the safety latch on the hoist. To check this raise the hoist, close off the air supply and open the air bleed valve on the air reservoir. If the hoist lowers more than 50 mm then the latch is not working.
- Check the condition of the probe carriage guide rollers, if worn, replace. The probe carriage should move both vertically and horizontally in a smooth operation.
- Check the operation of the each of the Metallurgical Samplers by rotating the SAMPLER switch to CUT. Refer EH Sampler Maintenance in Appendix C. Check the limit switches are operating freely. If not, clean and apply a light spray lubricant or drop of light oil.
- Also check the condition of the sample outlet hose and replace if necessary.
- Initiate a WinISA directory back up. Use the CD-R or back up to a suitable network location as appropriate. Instructions are provided

in the WinISA manual (This task may be the responsibility of the site network/computer administrator).

- Check the dry air indicator colour which is located in the pneumatics box on the carriage. Ensure it is purple indicating a dry air stream. If indicator is blue and air is flowing then seek to replace dryer unit. Check dry air regulator is set correctly at 50 kPa

3-Monthly Maintenance

This is usually performed by specialist trained by Thermo Fisher or a trained Site Technician; approximate duration of each task is 20 – 30 minutes.

- *Re-standardise* the analyzer. The Standard Biscuit is to be attached to the probe head for this. The procedure is explained in Chapter 6 under Stability Testing (Standardising) and should be carried out by the *metallurgical technician* who is responsible for calibrating the MSA.
- The Live Time Ratio (LTR) of the MEP gives an indication of some electronic problems which may be developing in the detector. In normal operation the LTR will remain fairly constant and will usually have a value greater than 0.5. It will never exceed 1.0 (100%) of course and will only approach that value when the probe is out of the pulp. The operating live time may possibly change by up to 5% as the count rates in the detector vary during normal probe operation. If the LTR begins to decrease markedly, it may indicate that there is an increase in microphonic noise or that the vacuum in the detector chamber is deteriorating.
- Check all air fittings for leaks. Check air cleaners and pressure regulator. Inspect the outside painted surface of the Air Receiver for damage (e.g. spots of corrosion). Isolate the main air supply to depressurize the system and open drain valve to drain any condensed water. Check air quality and if needed and fix main air compressor/refrigerator and filters if needed.

6-Monthly Maintenance

This is usually performed by Thermo Fisher Engineer or a trained Site Technician; approximate duration of each task is 15-20 minutes per MSA.

- Remove (if necessary) stirrer shafts from the motors and check the condition of the impeller. If replacing an impeller, ensure it is the same type as the original and cut to size if necessary. When reinstalling the stirrer, make sure it does not foul the moving carriage when lowering the probe before re-applying power. The impeller must also clear the bottom of the tank and the probe. An impeller too close (<10 mm) to the bottom of the tank may wear a hole in the tank over time. If the impellor is too close to the probe it

will cause increased wear rate of the impellor and the probe, and is likely to result in microphonics which will cause the probe to read erroneously.

- Check that the auto-drain air filter (located with the air isolator valve) is operating correctly and service or replace if necessary.
- Check the condition of the probe window and replace if it is discoloured, scratched or crinkled. The level of window cleaning required may be reduced or increased depending on the slurry type and condition; this will be determined during the commissioning of the MSA. If the window becomes too stained, its X-ray transmission may be reduced which will reduce the count-rates used for assay calculation. On the other hand, if the window becomes heavily abraded, holes may develop allowing moisture to ingress the probe. A window should be replaced as soon as it shows signs of severe precipitation/deposition or wear. Under normal operating conditions a window will last 3 to 6 months (This task would normally be performed by plant personnel who are licensed to work with radiation gauges).

12-Monthly Maintenance or Plant Shutdown

This is usually performed by Thermo Fisher Engineer or a trained Site Technician; minimum duration of each task is 20 minutes.

- Drain the analysis zones by lifting the dump valves and wash out any accumulated rubbish. Check for wear on the rubber lining if used, and reline or repair if required.
- Check for wear on the static sample cutters and replace if worn.
- Check Metallurgical Sampler cutter carriage bushes and belt for wear. Replace if required, or tighten belt where necessary. See Figure C-1.
- Check and replace blue sampler hoses if required.
- Check that the stirrers are working and that the impellers are not excessively worn. The slurry should be well mixed to avoid segregation of the slurry. However, the mixing should not be so turbulent that air is entrained. Segregation of the slurry may cause erroneous assay data. Also check that the stirrer impellers or shafts are not hitting the probe nor the bottom of the tank, otherwise a hole may appear in the bottom of the analysis tank through wear.
- Replace impellers if required.
- Remove the actuator on the water solenoid valve, (green supply line) and check its rubber diaphragm for wear. Replace as necessary.
- If the probe hoist air cylinder (pneumatic ram) is sticking, strip it down, clean and apply pneumatic grease before re-assembling.

Lubrication Schedule

There are no parts of the MSA-330 that require periodic lubrication. As a result there in no lubrication schedule.

Cleaning the Probe after Slurry Penetration

In the event of a window rupture – if slurry has penetrated through the back-up window and into the insides of the lower probe, it is necessary to clean out the slurry or residue thereof and wash the components, including the source, in pure alcohol (e.g. ethanol or methanol), flush with distilled water then dry thoroughly with warm air.

Note Inbuilt safety devices will have registered a fault if slurry or any other form of moisture has penetrated the probe. Consequently the MSA will revert to "manual" mode and will not lower the probe or respond to other WinISA commands. ▲

Warning Permanent damage may result if hot air is used on the electronic components in the lower probe. ▲

This cleaning and inspection must only be carried out by an authorised person (i.e. a person authorised to use and handle radioisotopes and radiation gauges, usually an RSO) who should inspect the probe and remove any signs of slurry (or water).

Once the components are clean and dry, replace the window assembly. A detailed description of how to replace a broken probe window is given in section Replacing the Probe Window later in this chapter.

It is then important to regularly (every 3 to 6 months) inspect the beryllium window on the front surface of the radioisotope source for signs of corrosion. Corrosion of the beryllium window appears as a white powder on the dark grey beryllium.

Warning Take care not to scratch, damage or even touch any of the grey metallic front windows of the source(s) or the detector itself as these are actually beryllium metal, a toxic substance. For more details refer to the MSDS in Appendix A. ▲

If slurry has entered the probe and is known to be of a corrosive nature then the isotope source should be inspected more often for signs of white crystalline build-up. Many isotopes used in XRF work have a Beryllium window. If corrosion of the source is evident, the head should be sealed immediately in a plastic bag until a wipe test can be performed on the source by the appropriate authority. In most cases the

appropriate authority will be the government regulating radiation authority.

Caution Use a mirror to inspect the radioisotope source to avoid exposure to the X-rays from the source during this procedure. ▲

Dismantling and Reassembling the Probe

The following procedures for dismantling and assembling the Multi-Element Probe rarely need to be performed. Refer Figure 8-1. Loading and unloading the radioisotope is a specialized task and must only be carried out by trained and licensed personnel (e.g. the site RSO or a Thermo Scientific engineer).

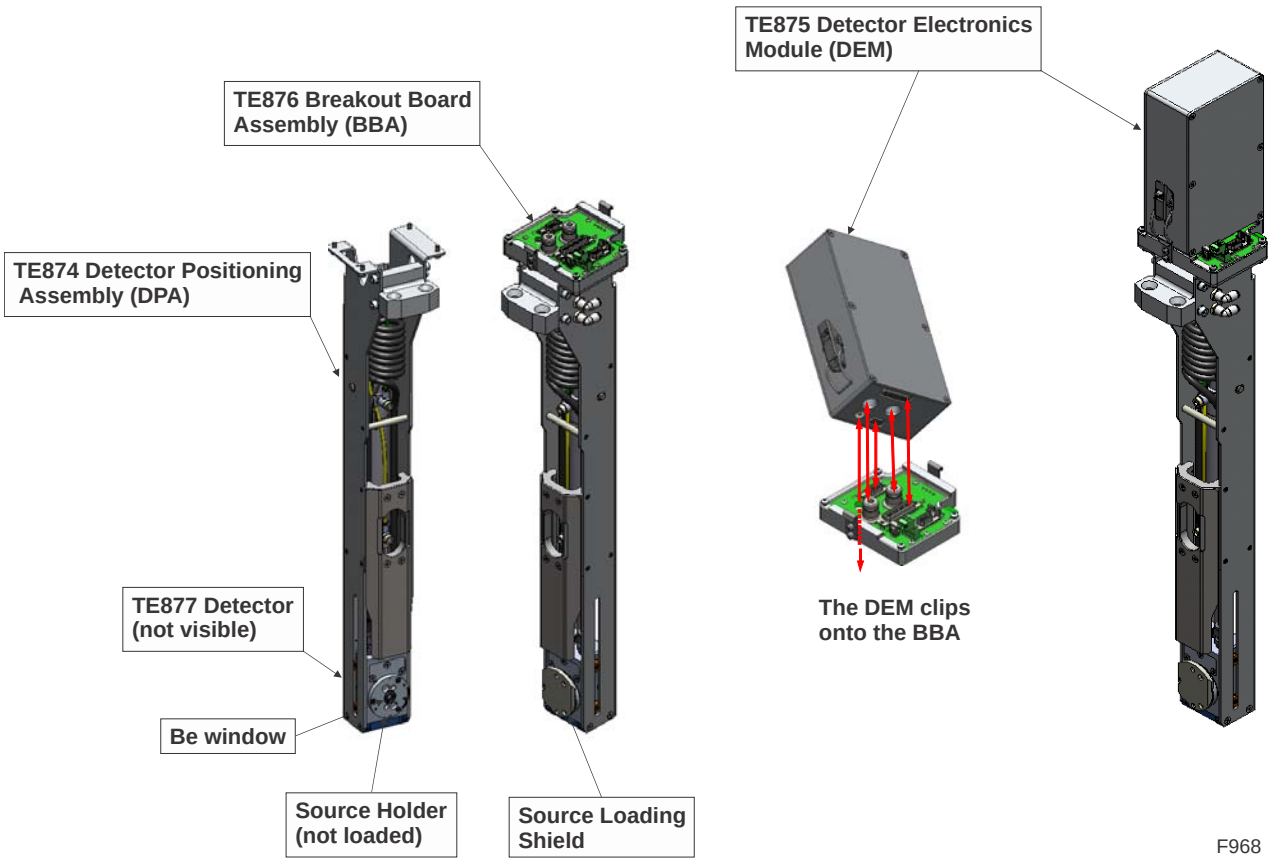


Figure 8-1. Identifying and assembling the main in-probe components

Caution Before proceeding, make sure the MEP is in the PARK position. This is indicating by illumination of the yellow PARK lamp and the words **Parked, Latched** on the OI. Ensure the source is retracted by checking the probe beacon is orange. Isolate the power and compressed air to the MSA. Remember however there is stored air in the receiver and this may be vented using the valve under the receiver.

Wear hearing protection before you open this valve. ▲

Dismantling the Probe

To dismantle the probe, follow these steps:

1. At the operating MSA, press the yellow PARK button and wait for it to illuminate. If the green RAISE lamp does not also illuminate, press and hold it until it does (allow about three seconds). This should bring the probe to the service position in the raised state. With the PARK lamp on the probe is locked and will not move while you attend to it.

2. Disconnect the probe cable assembly from J1 in Panel M. Refer Figure 7-6.

3. Open either door 1 or 2 to gain access to the probe. This will stop the stirrers for safety reasons; however you can restart them if needed by pressing the STIRRER OVERRIDE button. Keep in mind from this time on that the stirrers are rotating. Stand where the probe is facing away to ensure you are not irradiated.

4. Remove the Window Assembly by rotating the two square head captive bolts at the rear. Action should be taken to avoid radiation exposure before and after the window is removed.

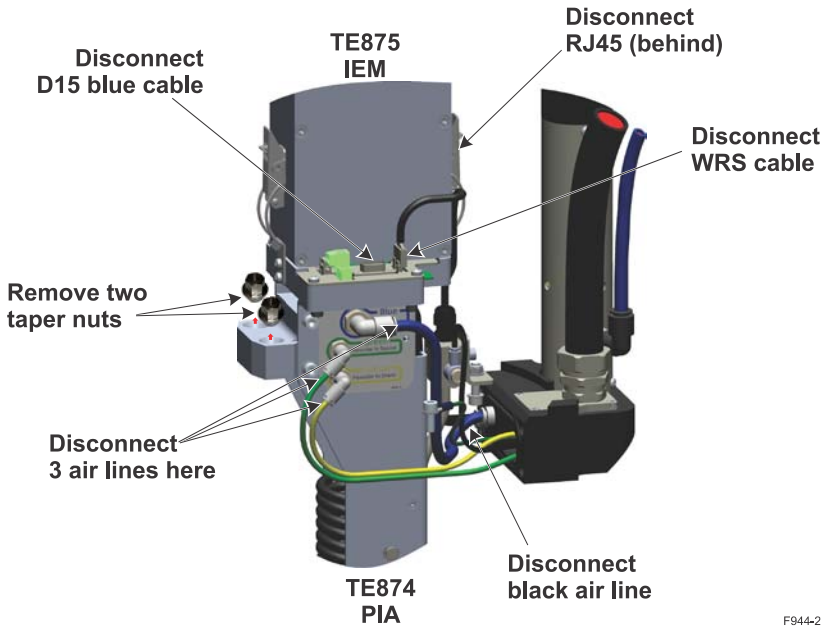


Figure 8-2. Preparing to extract the Detector Positioning Assembly (DPA)

Caution Handle the window from underneath and work from the back of the probe to prevent unnecessary low-level radiation exposure. ▲

5. Undo the single hexagonal bolt at the top of the Probe and carefully lift off the upper shroud. Pull the swing bracket down as follows:

6. 1. Pull out the spring loaded plunger located on one side of the hinge and hold with one hand.

7. 2. With the other hand firmly lift the bracket up and swing over gently with the plunger held out. Do not force bracket over without lifting bracket off rest position first.

8. Next disconnect cables and airlines as shown in Figure 8-2. The TE875 DEM may (optionally) be detached (see Figure 8-3) at this stage.

9. Carefully lift the DPA (with or without the DEM in place) out of the lower shroud and lay securely on a clean surface.

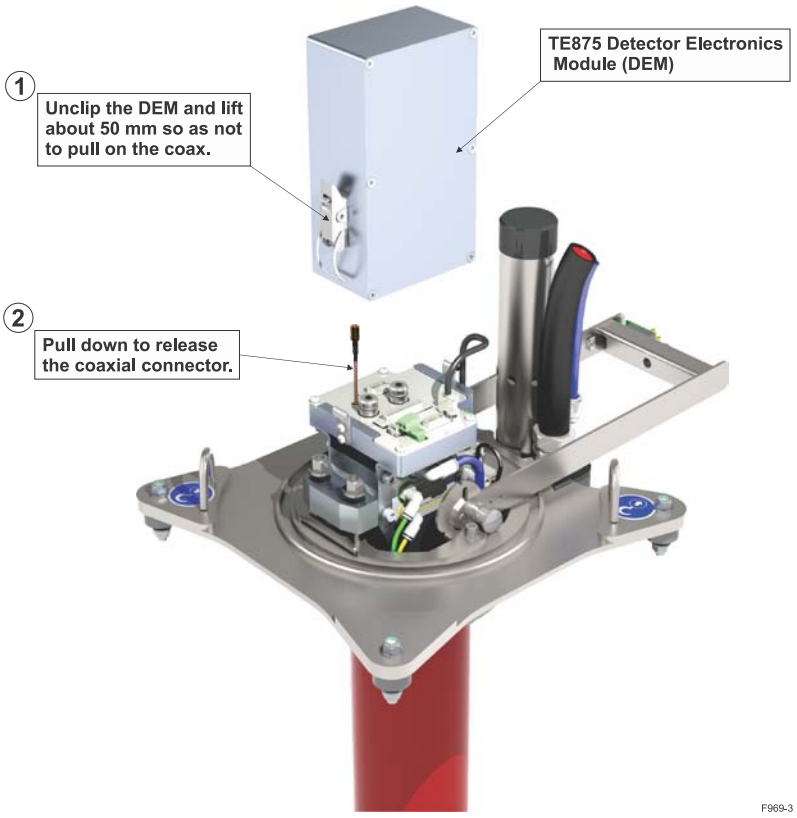


Figure 8-3. Detaching the TE875 Detector Electronics Module (DEM)

Reassembling the Probe

Reassembly is essentially the reverse of above. Take care to reconnect the coaxial cable under the DEM and avoid pinching cables or tubes. Do not over-torque the tapered nuts.

Refer to Installing the MEP in the Hoist on page 5-14 for complete proceedure.

Normally, the probe windows do not need regular cleaning because the flow of the slurry past the probe keeps the probe surfaces clean and polished. However, in some streams, particularly where the pH is high (>10) a precipitation may occur which then requires regular cleaning to remove the scale.

Note Scaling or precipitation on the probe window will change the count-rate measurement so it is important that regular window cleaning be implemented for such situations. The frequency of cleaning will depend on the extent of the scaling problem and will vary from one plant and one stream to another. ▲

When a severe precipitation problem occurs on the window of the probes such that cleaning is required on a shift basis, a solution to the problem may be to replace the window material type with one that is more resistant to a precipitation build-up. Such materials may be PTFE (Teflon), Kapton or PEEK. Consult Thermo Fisher Scientific for further information. If changing the window type doesn't provide a solution then they must be cleaned more regularly.

Note Always re-standardize the probe if the window material type is changed. ▲

Even though the slurry will normally keep the windows clean, there is no often need to worry about the windows being worn away – the probe windows are very tough 50 micron Mylar (polyethylene plastic) and will often last for at least 3 and perhaps 6 months, in even the most abrasive slurries.

Scratches can harbour contaminants which may affect the probe's readings and can compromise the window's integrity. Therefore the primary (slurry contact) window should be replaced if it shows signs of contamination and/or scratches that cannot be easily cleaned off.

If the window is physically ruptured or torn then the backup window may be ruptured also. In this case, slurry may have entered the probe. The inside of the probe and the detector then need to be thoroughly cleaned. This type of rupture is very uncommon and can normally be completely avoided by using screens to remove tramp material from the process streams.

Cleaning the Probe Window

The frequency of window cleaning varies enormously depending on the rate of build-up. In rare cases, the windows have to be cleaned once every shift while in other cases, they only need to be cleaned once per week or even less. Cleaning the window is a simple task and should take about two minutes to perform. The best way to find out how often the

window must be cleaned is to spot check the window over a period of a few days.

The procedure following is step by step instructions of how to clean the probe window.

Items required to clean the window are:

- Bucket or water or water hose.
- Dilute acid (e.g. hydrochloric). A concentration of 5% acid is usually best. Choose the acid that removes the precipitation easiest. Note that acid is only required if water alone doesn't remove the build-up.
- Cloth or paper tissue for wiping the window.
- Tongs to hold the cloth with (these are supplied in the Tool Box).
- Small mirror or piece of polished steel so that you can view the window. A telescopic mirror is supplied in the Tool Box.

Warning If using HCI acid, do not use more that 5% concentration, otherwise damage may occur to the 316 grade stainless steel probe parts and window wear will increase too. ▲

The procedure for cleaning the probe window is as follows:

1. Remove the probe from the slurry (analysis tank)
2. Wash the window by pouring water over it and the probe head and wipe with tissue or soft cloth using the long handled tongs provided.
3. Use the mirror to inspect the window for any signs of a build-up of precipitation – the window, should be perfectly transparent to light – if it isn't then it may be scratched and must be replaced. Refer section Replacing the Probe Window in this chapter. If it is still dirty then use the dilute acid.
4. When the window is clean, put the probe back into the operation.

Caution To avoid exposure to the low level radiation, you should be careful to ensure that no part of your body is within the primary radiation beam and adequate shielding is used when required.. ▲

Figure 8-4. Cleaning and Replacing the Probe Window

Replacing the Probe Window

The following procedure is a step by step instruction of how to change out the window of the probe. When you have had some practice at changing the windows, you should be able to perform the whole procedure in about 5 minutes.

If a window rupture occurred then an alarm message will be displayed on the WinISA computer and the RLC Operator Interface. The probe will be raised from the slurry and the flow of assay values will cease. The probe will also be raised from the slurry and you will have lost your online assay readings.

Before starting the procedure, the following tools and items should be collected:

- The socket driver for removing the window assembly (via square head bolts).
- A bucket of water or hose for washing the probe head if necessary before removing the window assembly.
- Some material (tissue or soft cloth) for drying the probe head and window assembly after washing.
- A container of petroleum jelly or equivalent for lightly lubricating the window assembly O-ring.
- A small mirror is also useful. The window of the probe can be inspected using the mirror without exposing you to any radiation.
- A set of laboratory tongs is useful for holding items in front of the probe to avoid exposing your hands to the radiation.
- Spare window assembly.

All the above items are in the Tool Box supplied with the equipment.

The procedure for changing the window is as follows:

1. Go to the analyzer that indicated a window rupture (there is no need to turn off the power, nor the bias voltage). The probe will already be raised on its hoist.

2. Wash all of the stainless steel of the probe head and the window. This can be done without exposing any part of you to the radiation.

Caution Be mindful not to expose yourself or others to radiation from the probe unnecessarily. ▲

3. Dry the probe head and window assembly using a soft cloth or paper tissue and the tongs.

4. Remove the Window Assembly by turning the two square head captive bolts with the spigot tool. The bolts will drive the flow cell outward from the front.

5. Swap the spare Window Assembly directly into place whilst the old one is taken to a clean work area for window refitting. The O-ring in the spare window assembly may need a light greasing with petroleum jetty.

6. Tighten the two square head bolts to secure the window assembly so that it is flush with the head.

7. Replace the main (broken) primary window in the window assembly immediately, in a clean and dry room, so it is ready for the next time a window change is required. Also replace the alarmed (backup) window too if it is broken or crinkled.

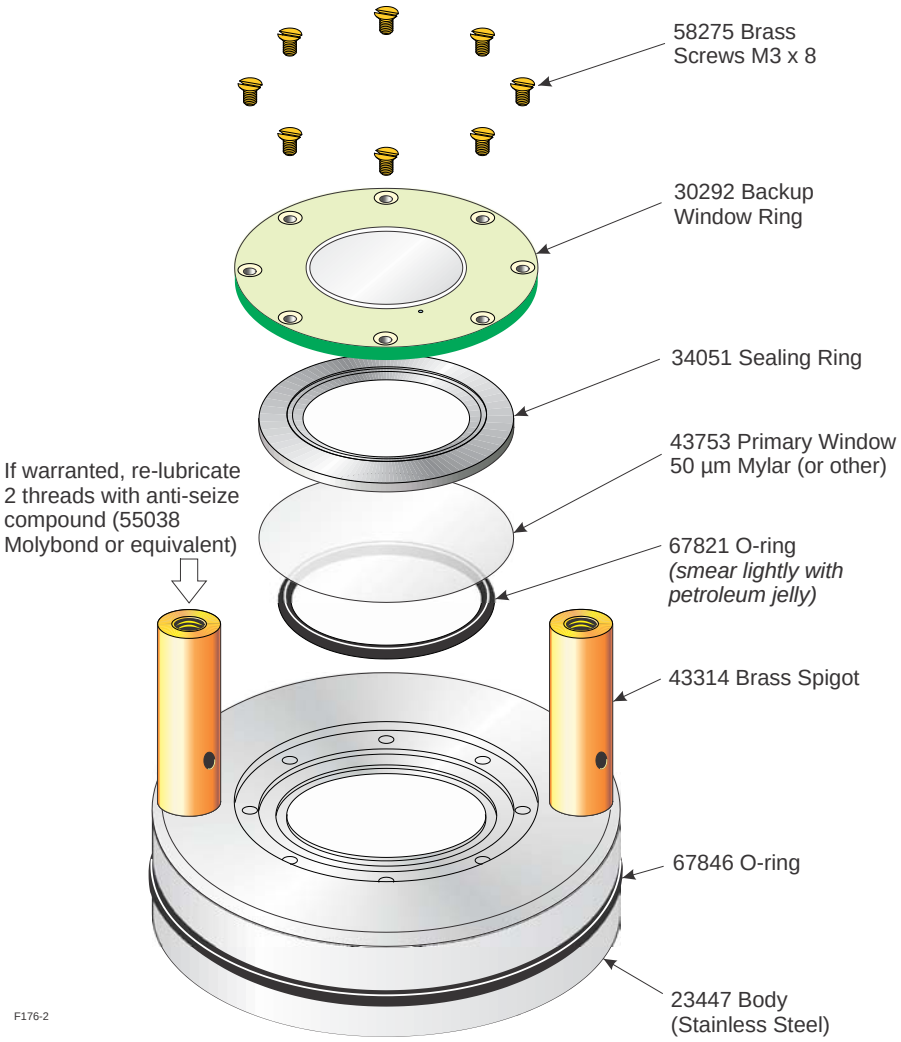


Figure 8-5. Exploded View of the MEP Window Assembly

Replacing the Primary Window

The procedure for replacing the plastic slurry content window is simply a matter of unscrewing the eight countersunk screws securing the backup window ring (AM233/40) and fitting a new 58.8 mm diameter disc of 50 micron thick clear Mylar window, in place of the old one. These windows are supplied in the Tool Box and can be re-ordered from Thermo Fisher Scientific when your stock is low. Figure 8-5 shows an exploded view of the Window Assembly.

Also remove any dirt or other debris or corrosion during this process. The O-ring should be very lightly greased with petroleum jelly. The rotational orientation of this ring is unimportant in this product.

Storage of Equipment for Extended Plant Shutdown

If the plant is to be shut down for a long period of time then it may be decided by the owners to remove the radioisotope from the MEP for safe storage. This is not a requirement by Thermo Fisher.

To remove the detector with its (shielded) source in place, follow the procedure in section Dismantling and Reassembling the Probe. This

provides for putting a radiation shield on the source holder. The detector should then be put into its metal stand with which it was originally supplied, and stored in a safe, clean and dry place.

If the source (with shield attached) must be removed from the detector then unscrew the three M3 screws that fix the source holder into the detector. This shielded source holder then needs to be stored in a safe place that is classified as the site radiation store with controlled access. The site RSO is responsible for carrying out this task and ensuring that the radioisotope is properly stored.

Note Replace the upper cover and window after removing the detector to ensure the inside of the housing remains clean. ▲

Warning If the radioisotope source is to be removed, it must be stored safely and the local radiation authority may require notification of its storage method and location. ▲

Chapter 9 Trouble Shooting

This section is written for those personnel who will oversee diagnosing electronic faults with the analyser system. It is intended to provide a guide to diagnosing where the fault may be.

The MSA is designed in a modular form so that faults can be isolated to a particular circuit board (PCBA) or sub-assembly. The PCBA or sub-assembly can then be replaced with a new one from the spare parts kit so that down time for the system is minimised.

Procedures in the following sections should help to quickly isolate the problem to one or two areas. At that stage, we recommend that you interchange spare parts from the spare parts kit noting which one makes the difference. If the faulty item is of significant value and appears outwardly repairable it can be sent back to Thermo Fisher for evaluation and quotation of repair or replacement (refer to Chapter 10 Service & Warranty).

Some Basic System Mechanical Checks

A loss of assay data can be attributed to a mechanical failure, it is important to carry out these basic system checks *before* proceeding with identifying any electronic problems in the system. Go and inspect the MSA in the plant and check the following:

On the status display, reached by pressing **<StatsDsp>** on the OI panel, some typical error messages that will stop the MSA operation (hence stop producing assays) are given below:

Table 9-1. Typical Error Messages

Message	Description/Cause/Remedy
PositionTest Req	A self (positioning) test must be performed. Check that the MSA is in **Auto RunMde** and select the **<AutoStrt>** option in menu level 5 so that a position test will start on power up and after fixing a failure, the MSA will restart. Check the **<ZoneMask>** (at menu level 7) has been entered and the **Zones Available** have been configured at menu level 5.
ErrRaisingPrb x	Check the probe carriage hoist. If the Hoist Ram is sticking it may not be able to raise the probe properly. Clean the Ram as required, see maintenance. Check for jamming of rollers and other mechanical parts. Check that the Up/Down sensor switches on the hoist are working. Replace if failed. May be seen in conjunction with **AirFl** message in **<StatsDsp>**
RevLsNotFound	The message implies the Reverse Limit Switch (a prox. sensor) has not detected the probe moving past it. This can be caused by a misaligned or very dirty prox., mechanical failure of the probe carriage to move past this sensor so check the movement of the probe carriage. The prox has a LED at the rear. Check that it illuminates. Otherwise, put the MSA into manual mode and try manually moving the probe to that sensor by turning the fly-wheel on the motor. If all fails check for 24V supply to the prox. sensor itself, or check the RLC input card in the MSA controller and change out as necessary.

Message	Description/Cause/Remedy
StuckAtLstZne x	The probe is not responding to commands to move to another zone or it does not have any other zones programmed. Check for anything that could stop probe moving.
ZoneNotFound x	Either the prox. sensor for that zone has failed or it just did not register the because it is dirty or set back more than 10 mm from the line of the flag. Clean and adjust as necessary. Also check that you have defined your available (online) zones under the menu option <ZneAvail> at menu level 5.
ZnePositionErr x	During the *Position Test*, or later the probe could not position itself at the zone indicated. This may indicate a prox. sensor failure or misadjustment.
FailedToLower	Ram problem, air failure or lower limit switch failure.
InvalidZneRqst x	A move command has requested a zone number that doesn't exist. If it is supposed to then go to IO level 7 and enter it at <ZoneMask> and then <ZneAvail> using menu level 5.
Parked,Latched	The **PARK** button has been pressed and the probe will be sitting in the zone defined as the *service bay*.
WndRpt	This message on the <StatsDsp> screen indicates a window rupture. This should raise the probe although it will be down if any access door is open or E-Stop is in force. Park the probe and change out the window assembly. Note: sending the probe to the service bay with a window rupture state in force will NOT lower it. It will stop above the service bay and electrically latch in place.
AirFl	This message on the <StatsDsp> screen indicates the compressed air supply pressure has dropped below the minimum or has ceased altogether. Check the air supply, if okay check pressure valves and switches on the probe carriage. Also check blue supply lines on the MSA.
Stirrer Run123456_____O/L x	The numbers of known running stirrers are shown after the word Run. In this example the first six are on. If a stirrer is not listed but seen to be turning it is likely that the stream concerned has been left out of the *Zone Mask*. Numbers after O/L are stirrers that are switched off at the panel or have tripped out as a result of an earlier overcurrent event. Check the **STIRRER** switches and/or the stirrer circuit breakers in Enclosure L.
Probe MotorOverload	The probe carriage drive assembly motor is in overload. Observe the VSD display.
CalibSampleFailed	This may be caused by: a. Too many sample cuts requested for the available time (of the calibration sample). b. Sampler problem, see Table 9-2.
Sampler Not Installed	When selecting samplers, this message indicates that the sampler has not been included in the samplers installed list, i.e. <ZoneMask>
ManMode	something has caused the MSA to drop out of *AutoMode* and into *Manual* (try putting it back to *Auto* by selecting the option <MenuMode> then entering your pass code and then select <AutoMode>. If it works and the probe starts operation, then you have fixed the problem. If the MSA doesnt start operation then check for other indicative errors on the OI panel, such as AirFl or one of the following:
GdOpen	indicates one or more access door(s) has/have not been shut properly, or may even be wide open, shut all doors properly.
WndRpt	indicates there is a broken window in the probe which needs to be changed out. Follow the procedure Replacing the Probe Window in Chapter 8.
EMStop	means someone has pressed the **EMERGENCY STOP** button. Do not release until you check why this has been pushed.

Message	Description/Cause/Remedy
Park	simply means the probe has been parked, possibly for maintenance. Check why before proceeding to release the **PARK** button.
Position TestReq	indicates the MSA has been reset, possibly through power failures or misappropriate menu entries. Try powering the MSA off, then on. On power up it should do a position test, if not, then check that the zones are actually available. If not, then the zone mask may have been deleted and needs to be re-entered. Go to IO Panel level 7 and enter it into the <ZoneMask>. Also observe any other message lines that appear on the OI panel. For example, the earlier mentioned one: RevLSNotFound.

Once the probe is in front of the suspect sensor, close the guard and put the MSA into *AutoMode*. It should then continue moving, if not check the *ZoneMask* and *ZoneAvailable* settings (see Figure 9-1).

If all this fails to get the MSA operational then proceed to checking the electronics.

Basic Set-up

This is a fundamental step which will have been done on initial start-up of the MSA. It is explained here in case it gets corrupted, deliberately or otherwise, so that it can be quickly put back as it was so the MSA can be put back in to service.

As Figure 9-1 shows the RLC has to be "told" how the streams and samplers are installed. This is done through the OI as described in To Re-establish RLC Setup Configuration in Chapter 7. Entry is performed at Menu Level 7 and requires level 3 password access. If you have kept a record of the *Zone Mask* and *Sampler Mask* from the initial installation simply re-enter those numbers. For a popular six stream MSA these numbers will both be "77". Otherwise compare your tank and sampler arrangement with Figure 9-1 and work out what your masks should be.

Having done that you need to decide which streams you want to measure for now. There can be many reasons to ***not*** analyse certain streams. One reason may be that tanks are not actually installed although the proximity switches are. This is the example situation shown in Figure 9-1 as it is normal practice of Thermo Fisher to include all the switchgear and sensor for a full complement of tanks even though less are ordered. This allows for the customer to add more tanks at a later date without doing a lot of wiring. Another reason could be that for operational reasons there is no slurry for a given tank.

So having decided on the Streams Available, you can proceed to enter that as an octal value at Menu Level 5. This requires a level 2 or better password. The octal number will be the same as the *Zone Mask* or a binary subset of it. Of course an easier and greener method is to simply switch the relevant STIRRER switches OFF and ON as you need. But remember this might result in the tank(s) sanding up over time, if some material continues to flow through unstirred tanks.

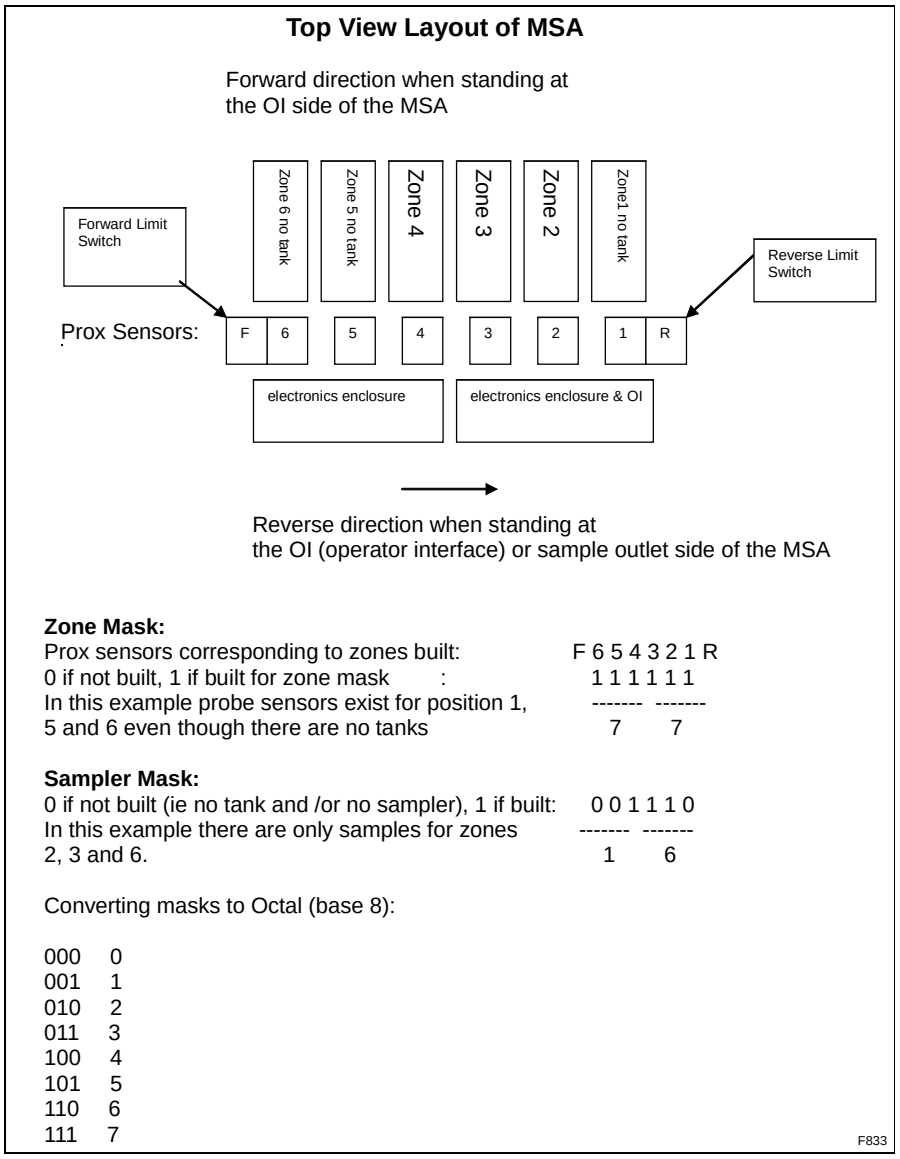


Figure 9-1. An example of how to calculate Zone and Sampler Masks

ISA Assays Differing from Shift/Check Samples

For problems with the MEP produced assays consistently reading different to the shift or check sample assays and assuming you are still getting assay readings from the analyser, check the following *before* proceeding with electronics diagnosis:

- Check the cleanliness of the probe window. A dirty window will change the count-rate measurements and hence the assay reading.
- Put the standard biscuit on the probe (refer to Stability Testing (Standardising) in Chapter 6) and measure the standard for two or three five-minute periods. The standard measurements obtained should not be too different to those being used in the calibration equation and should be stable.

If the standards are very different and unstable then measure for a *few hours* and check the time period since they were last measured. If it is up to a year or more since last measured then enter the new standards values into the software data base and then re-check the assay readings to see if they are more acceptable.

If the standard count-rates were measured more recently and are now very different don't apply them. There may be an electronic problem and you will need to proceed further in this chapter to find the fault.

Locating a Sampler Fault

The following table is a guide for diagnosing problems with the Metallurgical Samplers fitted to your Multi-Stream Analyser. The following table addresses mainly electrical problems unique to MSAs. For general mechanical maintenance refer to Appendix C.

Table 9-2. Sampler fault diagnosis

REF	FAULT	CAUSE	CHECK OR REMEDY
1	Sampler will not cut, and the Red LED on the AM987 is lit	Sampler module has timed out	Press RESET button or E-Stop, release and Restart. Then try again… Check AM664 is set on Speed 1 to 5, not 0. Try selecting another speed. Replace AM987 Replace AM054/01 (found in Sampler Head)
		Stalled because of motor or mechanical problem	refer to Appendix C
2	All samplers will not cut in any mode (i.e. Shift, Calibration or Manual Cut)	Sampler Power or control fault	Check AM665 is set on Speed 1 to 5, not 0. Try selecting another speed. Check OI for error message All AM987s must be present to complete the "busy" loop.
3	Sampler cuts one direction only	Control fault	Check/Replace AM987 and/or AM054/01
		Limit switch fault	Check/Replace Limit Switch
		Mechanical problem	refer to Appendix C
4	Sampler works in shift mode but not in calibration mode	Either too many or zero cuts requested in WinISA	Change number of cuts in WinISA configuration
		No communications between analyser and WinISA	Check/Repair communications to WinISA server
5	Sampler cutter arm action is jerky or doesn't always complete a cut	Mechanical problem	refer to Appendix C

Note: Always turn off and lock out the MSA power before replacing PCBAs or modules. ▲

Chapter 10 Service & Warranty

Customer Service

Thermo Fisher Scientific (*The Company*) provides telephone and email service support to its Customers. The Company also has a team of Customer Support Engineers (CSEs) available to visit site, on an casual basis or under a *Product Support Agreement* (PSA).

PSAs are an ongoing contract giving priority support and can be tailored to suit different customer needs. To enquire about a new or existing PSA please see Where to find more information.

Spare Parts

Refer to the MSA *Parts Manual* for a listing of all replaceable parts used in the MSA. An initial stock of common spare parts and/or consumable items may have been included in the original MSA shipment. In any event they can be ordered individually from your local Thermo Fisher office by quoting the part number and description given in the Parts Manual.

Allow two to six weeks delivery, ex Adelaide, depending on availability and location of your plant. To circumvent this delay, in the interest of keeping the analyzer running, Thermo Fisher recommends holding consumables and some spares on site. The Company will provide a priced list of recommended spare parts on request. See Where to find more information.

Keep in mind that non-consumable items of equipment supplied initially as original equipment and/or as new spare parts are covered by Thermo Fisher Scientific warranty.

Equipment Warranty

Please refer to the general Warranty Policy freely available on request from the Thermo Fisher Scientific Adelaide, Australia office.

Repairs

Many electronic parts including PCBAs are factory repairable. Refer to the Service Dept (see Where to find more information) for advice or package and label the part(s) and send them, along with contact details and a fault description to the address below. Company technicians will assess the reparability of the part and issue a quote for repair or exchange. Be sure to mention if you believe it is under warranty.

Shipping Address	Thermo Fisher Scientific 18 Butler Boulevard Burbridge Business Park Adelaide Airport SA 5950 AUSTRALIA Attention: Repairs Department

Caution Do not dispatch radioisotope sources with equipment for repair. ▲

Warning An MEP detector requires extra care in warming up and special packaging for transport. Consult with Thermo Fisher before packing or shipping any detector. See Where to find more information ▲

Appendix A Material Safety Data Sheets

SAFETY DATA SHEET

according to Regulation (EC) No. 1907/2006
Version 4.0 Revision Date 21.07.2010
Print Date 24.06.2011

1. IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

Product name : Beryllium

Product Number : 459992
Brand : Aldrich

Company : Sigma-Aldrich Pty. Ltd.
12 Anella Avenue
CASTLE HILL NSW 2154
AUSTRALIA
Telephone : +61 2 9841 0555 (1800 800 097)
Fax : +61 2 9841 0500 (1800 800 096)
Emergency Phone # : +44 (0)8701 906777 (1800 448 465)

2. HAZARDS IDENTIFICATION

Classified as hazardous according to criteria of NOHSC. - HAZARDOUS SUBSTANCE. DANGEROUS GOODS.

Risk advice to man and the environment
Toxic if swallowed. Toxic: danger of serious damage to health by prolonged exposure through inhalation. May cause cancer by inhalation. Very toxic by inhalation. Irritating to eyes, respiratory system and skin. May cause sensitization by skin contact.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Formula : Be
Molecular Weight : 9.01 g/mol

CAS-No.	EC-No.	Index-No.	Classification	Concentration
BERYLLIUM FOIL				
7440-41-7	231-150-7	-	T+, Carc.Cat.2, R49 - R25 - R26 - R36/37/38 - R43 - R48/23	-

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for fire-fighters
Wear self contained breathing apparatus for fire fighting if necessary.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Wear respiratory protection. Avoid dust formation. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.

Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains.

Methods for cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.Avoid exposure - obtain special instructions before use.
Provide appropriate exhaust ventilation at places where dust is formed. Normal measures for preventive fire protection.

Storage
Keep container tightly closed in a dry and well-ventilated place. Store in cool place.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Update	Basis
BERYLLIUM FOIL	7440-41-7	TWA	0.002 mg/m3	1995-05-01	Australia. Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment
Remarks	Probable human carcinogen ACGIH is the documentation source				
		TWA	0.002 mg/m3	2005-08-01	Australia. Adopted National Exposure Standards for Atmospheric Contaminants in the Occupational Environment
	Probable human carcinogen ACGIH is the documentation source				

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N100 (US) or type P3 (EN 143) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands. The selected protective gloves have to satisfy the specifications of EU Directive 89/686/EEC and the standard EN 374 derived from it.

Eye protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	Foil

Safety data

pH	no data available
Melting point	1,278 °C - lit.
Boiling point	2,970 °C - lit.
Flash point	no data available
Ignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Density	1.85 g/cm3 at 25 °C
Water solubility	no data available

10. STABILITY AND REACTIVITY

Storage stability
Stable under recommended storage conditions.

Materials to avoid
Alkali metals

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Nature of decomposition products not known.
Hazardous decomposition products formed under fire conditions. - Nature of decomposition products not known.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Inhalation: Irritating to respiratory system.

Inhalation: Irritating to respiratory system.

Inhalation: Irritating to respiratory system.

LD50 Intravenous - rat - 0.496 mg/kg
Remarks: Liver:Hepatitis (hepatocellular necrosis), zonal.

LD50 Intratracheal - rat - 51 mg/kg

Irritation and corrosion

no data available

no data available

Sensitisation

May cause allergic skin reaction.

Chronic exposure

Carcinogenicity - rat - Intratracheal
Tumorigenic:Neoplastic by RTECS criteria. Lungs, Thorax, or Respiration:Tumors. Lungs, Thorax, or Respiration:Bronchiogenic carcinoma.

Carcinogenicity - rabbit - Intravenous
Tumorigenic:Equivocal tumorigenic agent by RTECS criteria. Musculoskeletal:Tumors.

Possible human carcinogen

IARC: 1 - Group 1: Carcinogenic to humans (BERYLLIUM FOIL)

Genotoxicity in vitro - Human - HeLa cell
DNA damage

Genotoxicity in vitro - mouse - Ascites tumor
DNA damage

no data available

Potential Health Effects

Inhalation	May be fatal if inhaled. Causes respiratory tract irritation.
Skin	May be harmful if absorbed through skin. Causes skin irritation.
Eyes	Causes serious eye irritation.
Ingestion	Toxic if swallowed.

Additional Information

RTECS: DS1750000

12. ECOLOGICAL INFORMATION

Elimination information (persistence and degradability)

no data available

Ecotoxicity effects

no data available

Further information on ecology

no data available

13. DISPOSAL CONSIDERATIONS

Product
Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

ADR/RID
UN-Number: 3288 Class: 6.1 Packing group: II
Proper shipping name: TOXIC SOLID, INORGANIC, N.O.S. (BERYLLIUM FOIL)

IMDG
UN-Number: 3288 Class: 6.1 Packing group: II EMS-No: F-A, S-A
Proper shipping name: TOXIC SOLID, INORGANIC, N.O.S. (BERYLLIUM FOIL)
Marine pollutant: No

IATA
UN-Number: 3288 Class: 6.1 Packing group: II
Proper shipping name: Toxic solid, inorganic, n.o.s. (BERYLLIUM FOIL)

15. REGULATORY INFORMATION

Labelling according to EC Directives

Hazard symbols

T+	Very toxic

R-phrase(s)

R49	May cause cancer by inhalation.
R25	Also toxic if swallowed.
R26	Also very toxic by inhalation.
R48/23	Also toxic: danger of serious damage to health by prolonged exposure through inhalation.
R36/37/38	Irritating to eyes, respiratory system and skin.
R43	May cause sensitization by skin contact.

S-phrase(s)

S53	Avoid exposure - obtain special instructions before use.
S45	In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

Restricted to professional users.

16. OTHER INFORMATION

Further information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Co., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

Appendix B Power Details & Electrical Schematic

Table B-1 shows power details for a typical 6-stream MSA with standard 0.25 kW stirrer motors. Other configurations will draw more or less current. Thermo Scientific MSAs are produced in two standard configurations essentially to suit 50 Hz or 60 Hz countries but can be ordered to operate on any three phase voltage from 380 to 600 and either 50 or 60 Hz. This must be specified at time of ordering.

Table B-1. Power Details for basic AM800/30

Model	Power	Frequency	Max. Rated Current	Max. Power Consumption
AM800/30	400 V ~ 3 Ø or 460 V ~ 3 Ø	50 Hz 60 Hz	7 Amps	MSA with 5 x 750 Watts motors = 9.65 kVA MSA with 10 x 750 Watts motors = 19.30 kVA

Appendix C EH Sampler Maintenance

This appendix applies to the Thermo Scientific AM643/12 family of Environmentally Hardened (EH) Cross Cut Samplers. It describes the correct method of lubrication and adjustment to ensure reliable operation and long life.

Description of the Sampler Head

The Thermo Scientific AM643/12-260 Cross Cut Metallurgical Sampler is based on a molded polyurethane cutter that is driven by a linear actuator (Sampler Drive). The cutter is supported by a sliding carriage running on a pair of guide rails. It is belt driven by a small DC motor. The cutter directs a small volume of slurry (typically 50-100 ml per cut) into a bucket or tundish along a down-sloping soft polymer hose. The motor ensures that the cutter travels at constant speed behind a weir over which the slurry is falling. At each end of its travel the cutter is retracted or parked beneath a deflector cover intended to prevent slurry entering the cutter between cuts. A cut is defined as a single stroke from left to right *or* right to left.

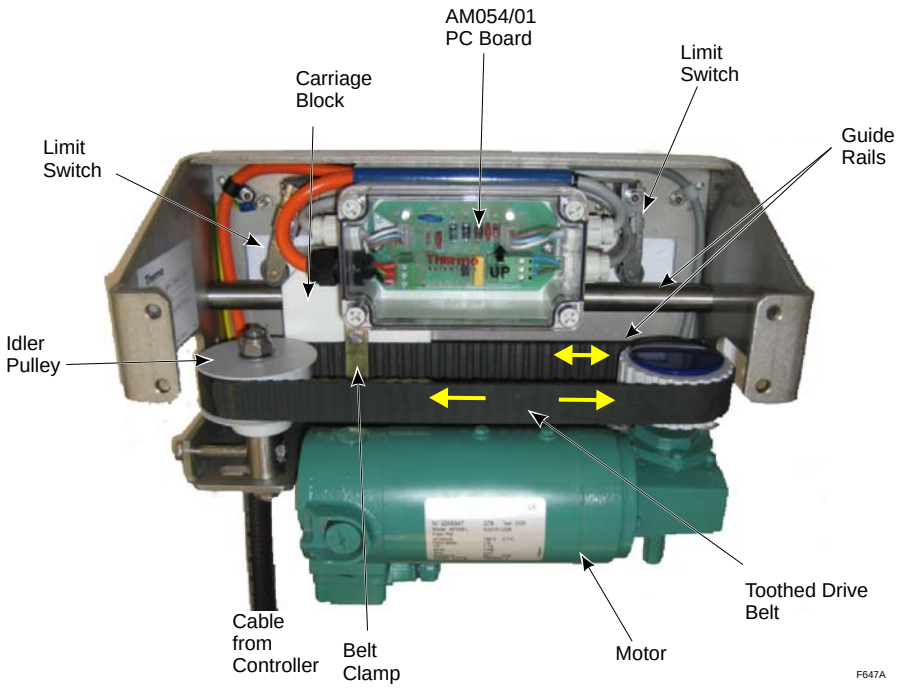


Figure C-1. The Main Parts of the Sampler Drive

Figure C-1 shows the Sampler Drive Head. This is the mechanism that moves the cutter from side to side. The important parts of the drive head (in this context) are the two polished stainless steel guides and the carriage block that slides on them. Also critical is the sample hose shown attached to the cutter in Figure C-4.

Routine Maintenance

The sampler is designed to eliminate most routine maintenance. The carriage block and idler wheel are made from special plastic that does not require lubrication.

Note Do not apply any lubricant to the guide rods ▲

Clean the Guides and Other Checks

It is good idea to clean the guides on a regular basis. The frequency can be determined by the conditions at each site. Try once per month to start with. Wipe the rods with dry clean cloth. Do not use solvent or cleaning agents.

1. If possible, stop the sampler while it is parked on its left side (viewed from the hose). This gives you the best access.

2. **Isolate the sampler power** so it will not move and cause injury. On the MSA every sampler has its own isolator switch that can be set to OFF whilst leaving every other sampler and the MSA cycle running as normal.

3. If possible, stop or reduce the volume slurry entering the tank. This may not be easy to do. If the plant has slurry-on-demand control as offered by Thermo Fisher and other vendors, this should be switched to Stop Sample.

4. Remove the sampler's front cover, held in place by four hex bolts.

5. Use a 10 mm spanner to undo the two hex bolts holding the belt clamp. Remove the clamp or just loosen it.

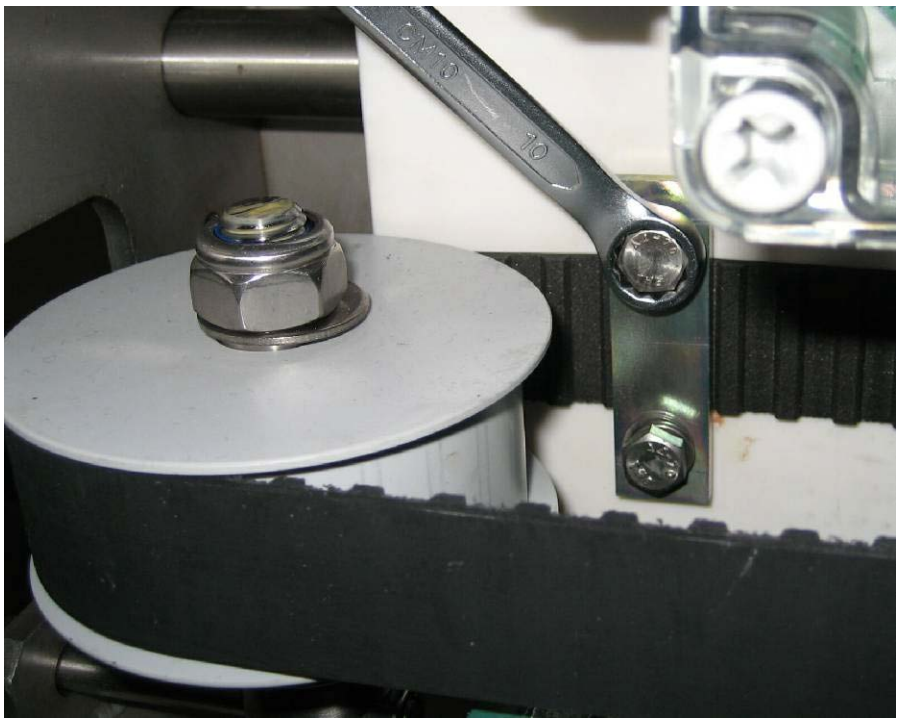


Figure C-2. Removing Belt Clamp

6. You should now be able to push the carriage from side to side.

7. Proceed to clean dirt from the guides. You should run the carriage back and forth as you clean to expose dirt on the guides for you to wipe away. You can rotate the guides to clean their back sides as required. If required you will need to loosen the two hex bolts at left of the frame to do this. If the guides will not rotate easily you can use a gripping tool, but only near the ends so as not to damage the working surfaces.

8. Check that the limit switches are operating freely. If not, clean and apply a light spray lubricant or drop of light oil.

9. Tighten the end bolts if you loosened them earlier.

10. Check belt tension and readjust if necessary by undoing the lock nut under the left idler pulley and then tightening belt by using the adjusting bolt. Do not over tighten belt. Once adjusted retighten lock nut under pulley. Refer Figure C-3.

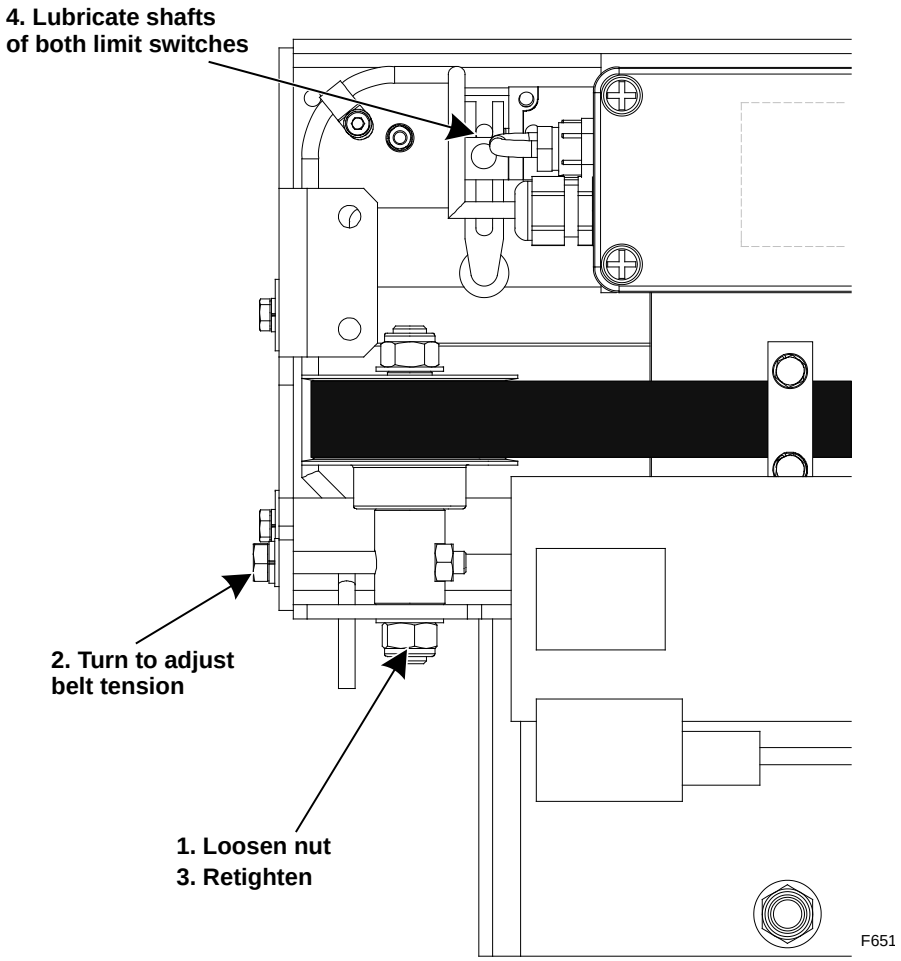


Figure C-3. Adjusting Belt Tension

Check the Sample Hose

Check the sample hose parts to see if there are any cracks or tears. Replace if required. Check that the boot is in correct position and is secured with a zip tie.

Confirm that boot is flexible and clean it if needed. Refer Figure C-4.

Replace the cover on the sampler drive. The sampler may now be returned to normal operation.

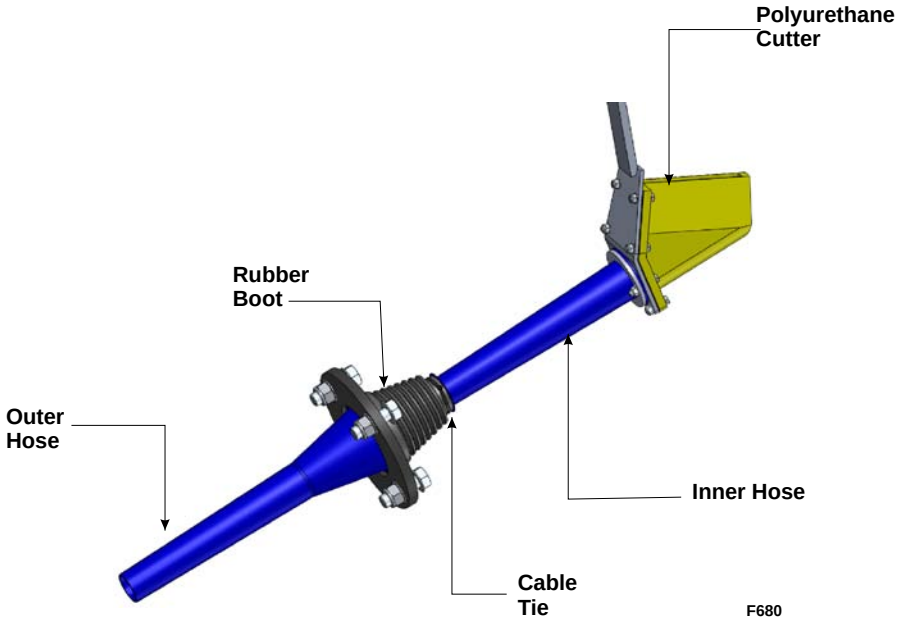


Figure C-4. The Sampler Hose

Appendix D Installation Drawings

(Equipment Arrangement Drawings)

Appendix E Slurry Sampling and Pipe work for Online Analysers

Refer following Technical Note 2: Guidelines for Slurry Sampling and Pipe work for Online Analyzers.

Technical Note 2

Guidelines for Slurry Sampling & Pipe work for Online Analyzers

Key Words
- Availability
- Metallurgical accounting
- Reduce blockages
- Reduce maintenance
- Slurry sampling

Introduction

The slurry sampling and transportation stages of any analysis system are often the major contributor to high maintenance costs and poor availability.

Maintenance costs and system availability can be optimised by careful design and implementation of the system. These guidelines provide a brief discussion of the main issues to be considered when designing and building a system.

General Guidelines

- The number of pumps required to transport the slurry streams to and from the analyzer should be minimised.
- Use gravity flow and existing line pressure wherever possible to transport the slurry to the analyzer.
- Return lines should be ganged together and returned to the process via gravity flow where possible - often they can be dumped into pump sumps on the ground floor of the plant.
- The distance from the main streams or primary samplers to the analyzer should be minimised. This will reduce the line pressure required (pressure lines) and the head drop required (gravity lines).
- The samplers, pipework and analyzer should be readily accessible in case of maintenance.

Step-by-step method of designing the sampling and slurry transport system.

Step 1 - Determine if the full flow of each stream can pass through the analyzer unit. The table below shows the allowed flow-rate ranges for various Thermo Scientific analysers. It is advantageous to pass the whole stream through the analyzer because it avoids sampling errors. However, for large streams it will be necessary to use a sampler to provide the required flow-rate continuously to the analyzer.

Note: for frothy streams like concentrates, a froth factor must be taken into account when calculating the maximum flow-rate. For example, a concentrate stream with a flow-rate of 10 m3/h and a froth factor of 3 has an effective flow-rate of 30 m3/h so it would require a Thermo Scientific MSA-500mm tank for full flow analysis.

Equipment Type	Tank Width (mm)	Maximum Flow rate (m3/h)	Recommended Range (m3/h)
MSA Mk 5	300	15	2 - 12
	400	25	5 - 20
	500	35	10 - 30
Duplex AnStat-230	400	20	5 - 20
	500	45	11 - 45
	600	80	20 - 80

Step 2 - Determine if the stream is used for metallurgical accounting or process control, then select the best type of sampler for each stream in consultation with Section 3 below. The primary sampler used and its location in the plant will determine where the analyzer must be placed. It may be necessary to look at a number of options regarding the location and type of samplers before making a final decision on the analyzer location.

Step 3 - Issues to consider when deciding the location of the analyzer

- Enabling gravity flow to and from the analyzer for as many as possible of the streams and;
- Minimising the length of all of the gravity flow lines to and from the analyzer.
- Minimising the spillage onto the analyzer unit.
- Access requirements for both operation and maintenance.

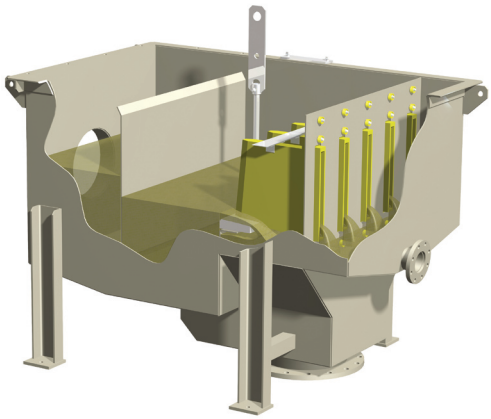
Methods of Sampling for use with online analysis systems

The most important considerations are that the sampler provides a truly representative and unbiased sample of the slurry stream and that the sampler is reliable and is easy to maintain and use.

Thermo Scientific SamStat-30C

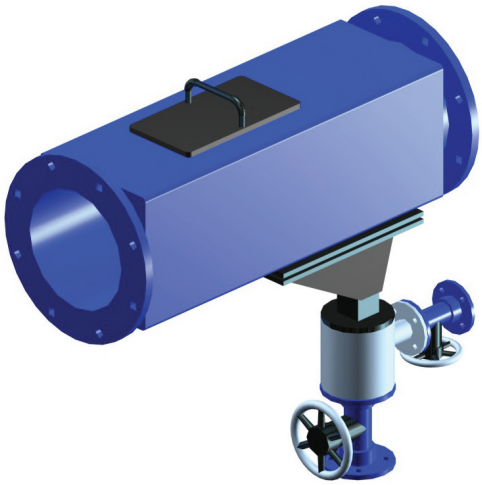
The SamStat-30C is now commonly used for sampling gravity flows of any flow rate. It provides a continuous, unbiased and proportional sample, is easy to maintain (no moving parts) and has low head loss. Multi stage sampling and other process functions (pebble screens, distribution) can be incorporated into the one unit.

They are commonly installed on horizontal pipes, launders or at the end of pumped/pressure lines. The outlet from the sampler can be flanged directly to the analyzer or can flow by gravity or pump to the analyzer. *The SamStat-30C will provide a sample suitable for metallurgical accounting.*



Horizontal Pipe Launder Samplers

A gravity type sampler (horizontal fixed cutter or launder sampler) is commonly installed on a horizontal slurry pipe or launder. The outlet from the sampler flows by gravity or pump to the analyzer.



This type of sampler can be used in all gravity flow situations in a pipe or where a pressure pipe sampler cannot be installed. A gravity sampler generally has a 50mm (2") NB sample outlet (flanged) and so a sample delivery pipe line with the same or larger NB size should be used. *These samplers cannot be used for metallurgical accounting purposes.*

We will only recommend these samplers where no other practical solution exists and do not recommend them for pipe sizes greater than 450NB.

Pressure Pipe Sampler

This is a commonly used sampling method for all pumped/pressurised slurry lines. These samplers are usually the cheapest to manufacture and install.

They also deliver a pressurised sample to the analyzer which normally simplifies pipe-work. A pressure pipe sampler should only be installed in a vertical section of pipe which is carrying the full slurry stream. It is normally installed near the outlet of a pump.

The internal diameter of the sample nozzle and the pipe-work between this and the analyzer must be selected so that the pressure pipe sampler will provide the required flow-rate. The sample stream flow-rate from a pressure pipe sampler is a function of:

- The internal diameter of the sample nozzle- this can easily be adjusted by changing the size of the sampler's nozzle
- Pressure in the main line at the sample outlet and the pressure drop between the sample outlet and the analyzer

These samplers cannot be used for metallurgical accounting purposes. We will only recommend these samplers where no other practical solution exists.

Sump Pump

In some cases the only practical method of obtaining a sample is to install a submersible pump directly into a *well mixed* tank of slurry (eg. the last cell of a flotation bank for a floatation tailings sample). The most commonly used sump pump for this application is a 40mm NB (11/2"). For streams which have to be pumped to the analyzer, this method of sampling can be much cheaper than the alternative of a gravity sampler feeding a sump and then pumping it to the analyzer. *This method will not provide a metallurgical quality sample.*

Sampler type	Line type	Integration of all sampling stages	Direct flanged connection to analyzer	Metallurgical Accounting
SamStat-30C	Gravity	√	√	√
Horizontal pipe launder sampler	Gravity	X	X	X
Vezin/Arc	Gravity	X	√	√
Pressure Pipe	Pressure	X	X	X
Sump Pump	N/A	X	X	X

Sampler Installation
All samplers should be installed so that they are easily accessible in the event of a blockage.

Design and Installation of pipework
Pipework from a sampler to the analyzer and from the analyzer back to the process should be designed to minimise blockages and therefore reduce maintenance. The main requirements are:

- To supply a sufficient flow-rate of slurry to the analyzer.
- The transport velocity must be high enough to avoid sanding.
- Line/piping minimum diameter must be 3 times larger than the largest particle in the stream.
- Easy to access for maintenance.
- Should not have 'ups and downs' with line fully self-draining on shut down

Slurry Velocity
Generally, most base metals plants require a minimum line velocity of 1 m/s. To allow for surging of the plant and for pump wear, a minimum of 1.5 m/s is normally used in designing the pipework. With velocities above 1.5 m/s in small lines, head loss increases rapidly so always keep line velocities as low as possible to minimise pumping power and to reduce wear.

Minimum Velocity Requirement
Pressure Sample lines: at least twice the settling velocity of the densest, largest particle of solids.

Gravity flow lines: at least 0.3 m/s to avoid settling and blockages.

These lines should be kept to the slope shown in Figure 1. The slurry velocity required in a sample line depends on the particle size, the specific gravity, the percent solids (dilution) and the shape of the particles. A minimum slope of five degrees will usually cater for most products.

Please Note: We recommend the client performs test work or models their particular application to determine the minimum slope required for their particular product.

Installation of Piping
Pressure sampler lines should reach the highest point soon after the sampler and run steadily downwards from there to the analyzer.

Gravity sampler lines can drop vertically initially and then only run steadily downwards to the analyzer.

In all lines avoid bends as much as possible and *do not* use sharp or small radius bends - only use long sweep bends (Radius = 3 x Pipe Diameter).
Ensure all lines are be well supported to avoid 'ups and downs'

Particular care must be taken with non rigid pipe like HDPE (high density polyethylene).

Siphoning
In some cases unwanted siphoning may occur so this should be engineered out if necessary.

Length
The sample line length should be minimised, particularly for coarse streams (ie., P80 +150 micron). Lines 50mm NB and smaller may need careful design if greater than 40m in length.

Back Pressure
The sample line should have less back-pressure due to friction and head losses than in the main line. This is to ensure that a stagnation zone does not occur just upstream of the sample cutter in the main line, in which case the sampled stream would *not* be representative of the full slurry stream. Therefore the sample line *must not:*

1. Rise as high as the main line (Pressure Samplers only);
2. Have any constriction which has a smaller diameter than the diameter of the sample point itself - the pipe diameter should preferably be slightly larger than that of the ID of the point of sampling but not so large that the flow-velocity decreases to a point where settling may occur;
3. Have sharp bends (to minimise friction losses, wear and blockages) and should preferably have line-of-sight straight sections with a minimum number of curves with the largest reasonable radius of curvature.

See Figure 1 below for recommended slopes on pipes to allow for draining, to eliminate landslide and to avoid loss of siphon effect.

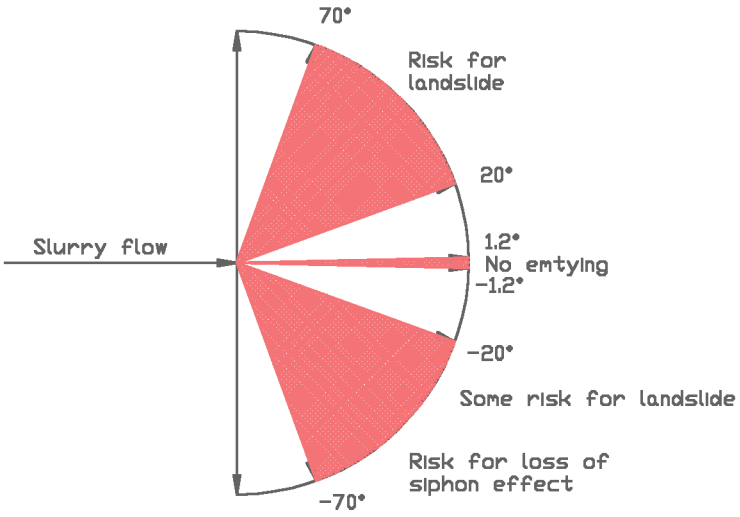


Figure 1.

Flushing Point

Pressure Samplers: a water injection point (pipe stub with fitting) should be provided just downstream of the sampler so that blockages can be cleared by back-flushing with high pressure water. A valve is required on the stub and also on the sample line downstream from the stub.

Gravity Samplers: a water injection point (pipe stub with fitting) should be provided just downstream of the sampler so the line can be cleared by back-flushing with high pressure water. A valve is required on the stub and also on the sample line downstream from the stub. This is only necessary if it does not contain an inspection port which can be used for clearing the sampler

Australia
+61 (0) 8 8208 8200
+61 (0) 8 8234 3772 fax

Chile
+56 (2) 335 3388
+56 (2) 335 1590 fax

China
+86 (0)21 6865 4588
+86 (0)21 6445 7830 fax

Europe
+358 9 3291 0788
+358 9 3291 0580 fax

India
+91 (20) 6626 7000
+91 (20) 6626 7001 fax

South Africa
+27 0 11 822 4120
+27 0 11 822 3982

USA
+1 (800) 488-4399
+1 (858) 452-9250 fax

www.thermoscientific.com/minerals

sales.auadl@thermofisher.com

Glossary

Anaconda PVC covered flexible metal conduit

SD Card Flash memory used in EPC

EH Environmentally Hardened

MSA Thermo Scientific Multi-Stream Analyzer

EMC Electromagnetic Compatibility

EMI Electromagnetic Interference (noise)

EPC Embedded PC

FLE Term used for Liquid Nitrogen (LN_2) storage unit with a high storage capacity (from 50 litres to 400 litres), also known as a **PLV**.

ISA In-Stream Analysis (name given to the Thermo Scientific on-line analysis system because it is mainly based on immersion probe technology)

LN_2 Liquid Nitrogen (extremely cold inert liquid to for cool the MEP detector).

Low Voltage defined by AS3000 to be any voltage greater than 50V a.c. or 120V d.c. but less than 1000V a.c. or 1500V d.c.

LTR Live-Time-Ratio (the percentage of time the MEP electronics actually processes information)

MCB Miniature Circuit Breaker

MEP Multi-Element Probe (high sensitivity XRF analysis probe capable of measuring up to eight elements and slurry density simultaneously)

MSDS Material Safety Data Sheet

PCBA Printed Circuit Board Assembly

PLC Programmable Logic Controller

PPE Personal Protection Equipment

PSEM Probe Support Electronic Module

RARP Regression Analysis Program (Thermo Scientific software package for performing calibrations)

RLC Remote Logic Controller – a Thermo Fisher proprietry

RS-485 half duplex Serial Communication Protocol

RS-232 full duplex Serial Communication Protocol

RS-422 full duplex , 4 wire Serial Communication Protocol

s.d. Standard Deviation in counting statistics

VSD Variable Speed Drive – also called an inverter or Variable Frequency Drive (VFD).

WinISA The main software package that runs on the central computer, used for capturing and displaying assay data and configuring the system

XRF X-ray Fluorescence – an established method of elemental analysis