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SWTC Flow Loop

Maintenance Procedures

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1 INTRODUCTION

The SWTC multiphase flow loop is a process plant comprising of various equipment and instruments involving different technologies integrated together to work in synchronization. It is a closed loop system operated under different conditions of temperature and pressure. The 3 phases (Oil, Water and Gas) composition can be varied in the loop based on the requirements and this makes it all the more important to maintain and operate the system under high degree of supervision.

Maintenance is an important aspect for the long life of the process plants. The monitoring and diagnostics of the overall health of the Flow Loop is taken care by splitting the maintenance of the processes in different categories. The main four categories are:

1. PREVENTIVE MAINTENANCE

Preventive maintenance is the practice followed almost everywhere in the process industry to keep all the instruments and equipment in the best working state. It is a way to monitor the devices at regular intervals and rectifying the issues before it leads to failure of the device.

2. FUNCTIONAL MAINTENANCE

Functional maintenance is more of a reactive check as compared to the preventive check explained in preventive maintenance. Functional maintenance is mainly carried out when it is clear from the preliminary checks that the device is inaccurate or faulty. It may lead to recalibration process or in the worst cases to replacement of the device.

3. FACILITY MAINTENANCE

This is to keep the facility (Security, Lights, AC, Air Supply, Fire Control etc.) in working conditions.

4. OPERATION MAINTENANCE

As Flow Loop is a process having different chemicals flowing in the pipes at different pressures. It has operation requirements which should be carried out in certain period of time. The details are explained in the Operation Maintenance (Section 11).

This document aims at demonstrating the flow loop maintenance procedures by covering all the aspects of operation of Flow Loop one by one. The environment factor, corrosion control, 6S methodology, preventive maintenance of equipment, machinery and instruments are the different aspects to be considered for keeping the system healthy and running in the long run. This document covers all of them in different sections. The frequency of maintenance is mentioned with each maintenance procedure. Based on the maintenance requirement of a particular month , the Flow Loop supervisor needs to come up with a maintenance calendar for that month (MaintCalender_Mnthly.xlsx) in the beginning of the month. The maintenance calendar is to be followed by covering the procedures mentioned in this document and report for each maintenance is to be kept in the maintenance register. At the end of the month, all the required procedures should be complete with reports.

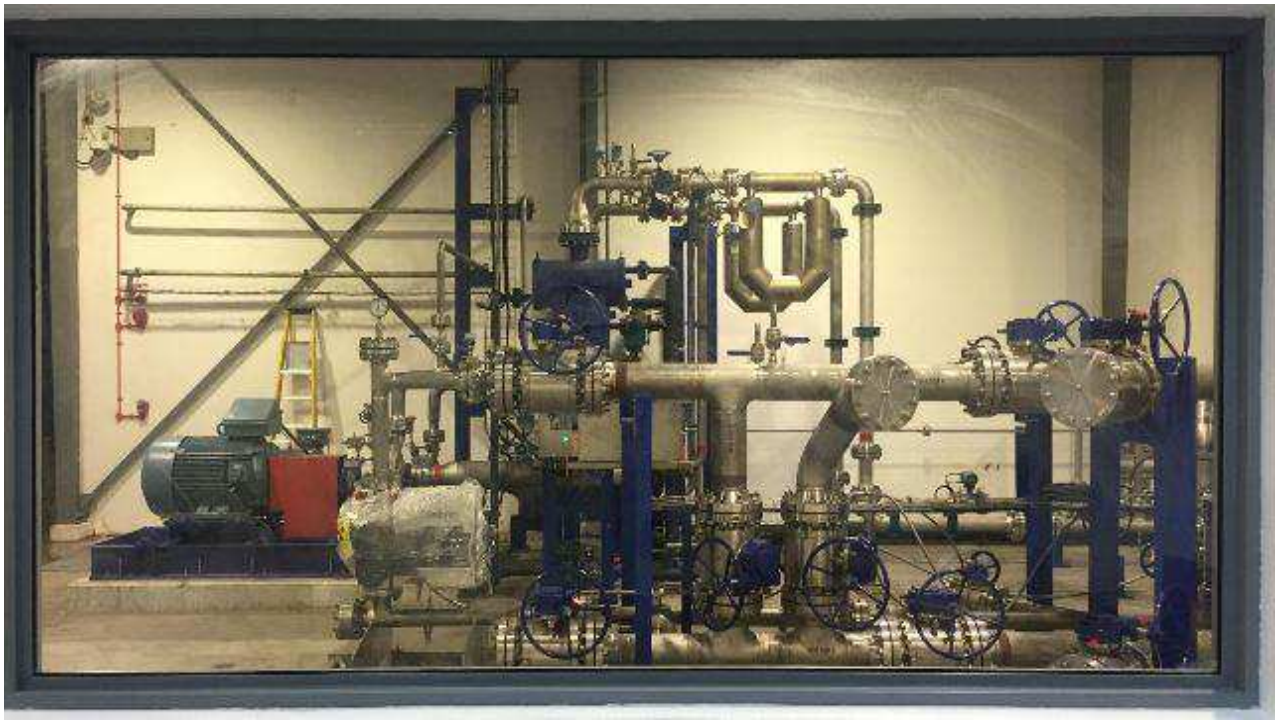


Image 1: Flow Loop, SWTC, Schlumberger

1.1 Scope

This document is used for the following purposes:
- Describe the various aspects for maintenance in SWTC flow loop.
- Procedures of maintenance of different devices.
- Define the frequency of maintenance of various devices.
- Preparation of Yearly Maintenance Schedule (FL_Maint_Yearly.xlsx).
- Preparation of Monthly Maintenance plan (FL_MaintCalender_Mnthly.xlsx)
- Recording the maintenance plan as reports.

1.2 Abbreviations and Definitions

SWTC	Singapore Well Testing Center
FL	Flow Loop
SCADA	Supervisory Control and Data Acquisition
PLC	Programmable Logic Controller
QHSE	Quality Health Safety Environment
MPFM	Multi Phase Flow Meter
E-Stop	Emergency Stop
6S	6 Sigma
MPFM	Multi Phase Flow Meter
REMS	Research Engineering Manufacturing Sustaining
HARC	Hazard Analysis and Risk Control
DAUDA	Drift Analysis using Data Acquisition
VFD	Variable Frequency Drive
MTTF	Mean Time to Failure
PLQS	Product Lifecycle Quality System

2 CLEANING

Flow loop is an area comprising of various mechanical, electrical and electronic devices. Keeping the area clean and tidy not only prevents any dust ingression into the machinery but also helps to reduce the issues like corrosion, noticing leakage from any part of the system, keeping the environment safe and thus helping to keep the plant operating with minimum disruption.

The types of cleaning required in Flow Loop is divided into various areas such as:

- Dry Cleaning
  This is cleaning using broom for floor and damp cloth for the piping, equipment and instruments. This is mainly to remove dust and debris from the surface.

- Wet Cleaning (Water Jet)
  This involves using water jet and is required periodically for pressure cleaning of the area and removing stagnant water from secondary containment pallets and sumps.

- Chemical Cleaning (Rust Prevention, Mosquito Repellent)
  This is done periodically to prevent any rust development on the metal equipment and mosquito breeding in the drains and sump.

2.1 Floor/Area Cleaning

The Flow Loop Cleaning area is divided into various sections such as:

1. FL Process Section

   This is the main section of Flow Loop where we have most of the equipment and instruments. It comprises of pumps, motors, reference meter, instruments, piping and MPFM test skids.

Image 2: Flow Loop Process Section

2. FL Storage Section

   In this section, we have the 3 storage tanks, transfer manifold and separator units with instruments and safety devices.

Image 3: Flow Loop Storage Section

3. FL Electrical Room

   This room has the VFD's and control system cabinets for the pumps. It is a high voltage area (415 V) and have incoming and outgoing cables for all the electrical equipment.

Image 4: Flow Loop Electrical Room

4. FL Control/Client Room

   The Control Room is the area having the SCADA system for the operation and supervision of the Flow Loop facility and Client room is the adjoining room with the control room which will be used as sitting area for the clients visiting FL for witnessing the tests.

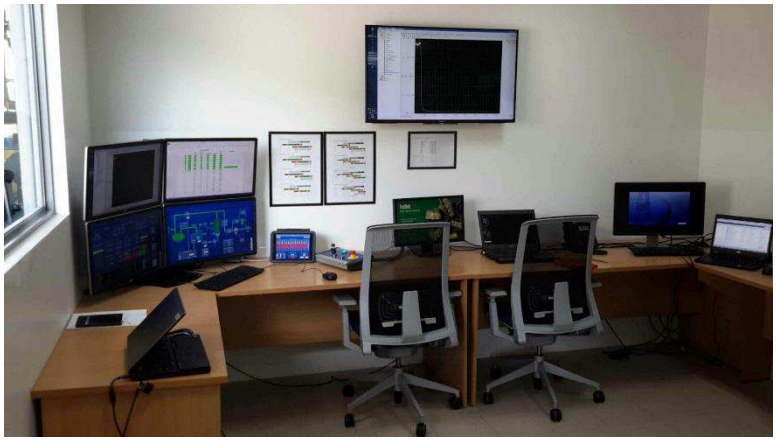


Image 5: Flow Loop Control Room

5. FL Storage Room

This is the warehouse of the Flow Loop. All the accessories, hoses, fittings, valves, flanges required in the Flow Loop are to be stored in the storage room at the dedicated locations marked with proper labels.

Image 6: Storage Room

The general cleaning of various areas is taken care as below:

AREA	TYPE	FREQ	RESPONSIBLE
Process Section	Dry Cleaning	Weekly	Contractor/SLB
Process Section	Wet Cleaning	15 Days	Contractor /SLB
Process Section	Chemical Cleaning	Weekly	Contractor /SLB
Storage Section	Dry Cleaning	Weekly	Contractor /SLB
Storage Section	Wet Cleaning	15 Days	Contractor /SLB
Storage Section	Chemical Cleaning	15 Days	Contractor /SLB
Electrical Room	Wet/Dry	Biweekly	Contractor
Control Room	Wet/Dry	Daily	Contractor
Storage Room	Wet/Dry	Weekly	Contractor

Table1: Cleaning Schedule with frequency

The frequency of Wet/Dry/Chemical cleaning is for reference could be changed based on requirement. It should be entered as plan in the monthly calendar for each month. The monthly calendar does not have the control room cleaning section as it is covered by facility contractor and is monitored separately.

The schedule as shown on maintenance calendar is to be followed for each month to cover all the areas and keep the Flow Loop clean and tidy. The calendar shown in Appendix-1 is the template used for each month to list down the cleaning performed on particular day and signed off each day by the responsible party taking care of the cleaning.

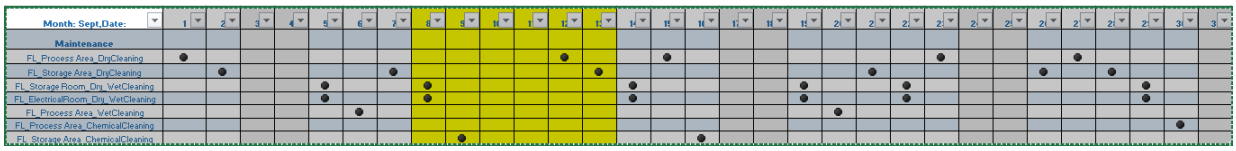


Fig 1: Monthly Maintenance Calendar for Cleaning

The monthly maintenance calendar is compared with signed off calendar and marked green for the task performed at the end of the month. The proposed calendar and signed of calendar forms a part of maintenance register as record.

3 HOUSEKEEPING

6S Methodology is followed and to be maintained for the complete area. The various areas defined for housekeeping are as below:

1. Control Room
2. Storage Room
3. Flow Loop Area
4. Parking Lot

6S Audit is carried out as a facility audit and the score for each month is updated and pasted on the accessible location in the Control Room. The score sheet is also kept in maintenance register for record purposes.

3.1 Control Room

Control Room should be free of any tools or PPE items. The cabinets need to have proper labelling and the location of PPE and documents is defined in PPE Cabinet and Document Cabinet respectively.

3.2 Storage Room

Storage Room forms the main location in the Flow Loop where all the spare items, tools, fittings, instruments are to be stored. This serves as the warehouse of the Flow Loop. It needs to be arranged with proper label and exact location of each item.

3.3 Flow Loop Area

Flow loop area is the process area containing most of the equipment, machinery and instruments. The rig-up, rig down of the testing meters with the Flow Loop is done in this area. Most of the physical activity

in Flow Loop is carried out in this place. It is necessary to make sure the tools, wires and equipment used previously for hook up should be removed after the job is over.

3.4 Parking Lot

Parking lot is the resting area of different skids of the Flow Loop. The parking area has different slots clearly marked for different skids, slot for nitrogen cylinder and mini crane. The skids if are not hooked up to the Flow Loop should be placed in the Parking lot.

Image 7: Flow Loop Parking Lot

4 SAFETY/ENVIRONMENT

SAFETY FIRST is an RULE followed throughout Schlumberger and it becomes all the more important for the hazardous areas. Flow Loop can be operated at max. pressure of 38 Bar and the gas flow can go to max. 630 m3/hr (Phase 1). This can create dangerous situations if the safety measures are not taken seriously or preliminary tests are taken for granted. To keep the system and environment safe and free of hazardous conditions various measures has been implemented.

The series of measures are as described as below:

4.1 Process Safety - Alarms

The complete Flow Loop can be controlled through a central control system having PLC's as the brain of the system. Some of the critical process situations are hard coded in the PLC to shut down the process whenever they occur. The conditions are listed as below:

EQUIPMENT						SIGNAL	INPUT			
TAG mnemonic	TAG	eqt N°	P&ID number	Status	Eqt Description	PLC N°	Variable tag 1	range Input	HH process1	HH value1
FLDBUS-PISH-1204-AIH-NA	PISH	1204	1102	NA	Compressor - Discharge pressure (A-3222)	FLDBUS	**Press_1204**	0 - 50 barg	SD_C101	39
PLC1-PISH-1601-AIH-NA	PISH	1601	1106	NA	Transfer pump - Discharge Pressure transmitter	PLC1	**Press_1601**	-1 to 30barg	SD_Transfert	29
PLC1-TISH-1617-AI-NA	TISH	1617	1106	NA	Transfer pump - Temperature switch high	PLC1	**Temp_1617**	0-100°C	SD_Transfert	70
PLC2-FI-1223-AIH-NA	FI	1223	1102	NA	Reference metering - Gas 2ary large flowmeter "PRESS"	PLC2	**Press_1223**	-0.979 to 55.2 bar	SD_C101	38
PLC2-TI-1235-AI-NA	TI	1235	1102	NA	Compressor - Bearing 1 DE temperature (A-3441)	PLC2	**Temp_1235**	0 - 150°C	SD_C101	110
PLC2-TI-1236-AI-NA	TI	1236	1102	NA	Compressor - Bearing 2 DE temperature (A-3442)	PLC2	**Temp_1236**	0 - 150°C	SD_C101	110
PLC2-TI-1237-AI-NA	TI	1237	1102	NA	Compressor - Bearing 3 NDE temperature (A-3443)	PLC2	**Temp_1237**	0 - 150°C	SD_C101	110
PLC2-TI-1238-AI-NA	TI	1238	1102	NA	Compressor - Bearing 4 NDE temperature (A-3444)	PLC2	**Temp_1238**	0 - 150°C	SD_C101	110
PLC2-TI-1239-AI-NA	TI	1239	1102	NA	Compressor - Motor winding temperature U (A-4342)	PLC2	**Temp_1239**	-50°C - 250°C	SD_C101	150
PLC2-TI-1240-AI-NA	TI	1240	1102	NA	Compressor - Motor winding temperature V (A-4342)	PLC2	**Temp_1240**	-50°C - 250°C	SD_C101	150

PLC2-TI-1241-AI-NA	TI	1241	1102	NA	Compressor - Motor winding temperature W (A-4342)	PLC2	**Temp_1241**	-50°C - 250°C	SD_C101	150
PLC2-TIC-1220-AIH-NA	TIC	1220	1102	NA	Gas reference - temperature transmitter	PLC2	**Temp_1220**	0 - 100°C	SD_C101	60
PLC2-TISH-1205-AIH-NA	TISH	1205	1102	NA	Compressor - Discharge temperature (A-3042)	PLC2	**Temp_1205**	0 - 150 °C	SD_C101	90
PLC2-TISH-1212-AIH-NA	TISH	1212	1102	NA	Cooling loop 1 - Temperature transmitter	PLC2	**Temp_1212**	0 - 100°C	SD_C101	90
PLC2-TISH-1233-AIH-NA	TISH	1233	1102	NA	Scrubber - Temperature transmitter	PLC2	**Temp_1233**	0 - 100°C	SD_C101	90
PLC3-PIC-1302-AIH-NA	PIC	1302	1103	NA	Water pump - Discharge pressure transmitter	PLC3	**Press_1302**	-1 to 40 barg	SD_P103	39
PLC3-PIC-1304-AIH-NA	PIC	1304	1103	NA	Oil pump - Discharge pressure transmitter	PLC3	**Press_1304**	-1 to 40 barg	SD_P105	39
PLC3-PISH-1329-AIH-NA	PISH	1329	1103	NA	E101 - Pressure transmitter	PLC3	**Press_1329**	-1 to 40 barg	SD_P103	39
PLC3-PISH-1330-AIH-NA	PISH	1330	1103	NA	E102 - Pressure transmitter	PLC3	**Press_1330**	-1 to 40 barg	SD_P105	39
PLC3-TIC-1307-AIH-NA	TIC	1307	1103	NA	Water pump - Discharge Temperature	PLC3	**Temp_1307**	0 - 100°C	SD_P103	60
PLC3-TIC-1314-AIH-NA	TIC	1314	1103	NA	Oil pump - Discharge Temperature	PLC3	**Temp_1314**	0 - 100°C	SD_P105	60

Table2: List of Critical Alarms

The critical alarms are to be checked **annually** to trigger shutdown of the system. The test data to be recorded as a part of the maintenance register.
The alarms are simulated from the HMI Settings tab for High and HighHigh values. The system will show alarm at the high value and shut down of the pumps should happen once the values are going above the HH value.

4.2 Emergency Stop Buttons

Emergency Stop is a mechanism to stop all the running pumps instantly in case some accident occurs or the situation goes out of control of the control system. E-Stop circuits are kept independent of the control system and the wires are directly connected to the incoming breaker of the VFD's and the motors to stop the power supply to the motors (by opening the incoming breakers) instantly and stop the pumps. Flow Loop has 8 emergency stop buttons distributed all through the process area.

E-Stop circuit of all the buttons should be checked **bi-annually** to make sure they are functioning as required.

4.3 Assessment against QHSE standard

Std 01: Driving and Journey Management

- Designated loading and unloading point for all delivery.
- Nitrogen truck reversing into gas cylinder storage area shall be guided.

Std 03: Personal Protective Equipment

- Hard Hat, Coverall/Lab coat, Safety glass, Safety shoes.
- Ear plugs for working for long period in the flow loop.
- No ring, metallic watch or jewellery during work
- Use appropriate gloves (Consider for Impact resistant, Cut resistant, Chemical resistant, or general work application)
- Use of Body Harness. Visually inspected before each use. Inspected at least every **6 months** and documented.

Std 04: Business Continuity, Emergency and Crisis Management

- Fire Warden – Flow Loop Operator shall ensure that in event of emergency evacuation, the flow loop operation is shut down and Operator shall act as fire warden to clear the flow loop area.
- First Aid box/First Aider – Available at the Production Area
- Eye Wash – Outside Flow Loop Shelter
- Spill responder – Flow Loop Operator is trained and Spill Kit available in the Flow Loop. Content to be checked as a question in the 6S **monthly** program.

Std 05: Training and Competency

- Setup Competency Matrix for Flow Loop. **Quarter review** required.

Std 06: Health

- Noise Survey. Employee who is working permanently in Flow Loop is requiring to undergo annual Audiometric examination. Site Survey shall be conducted once every **3 years** or as required based on the survey findings.
- Cleaning of flow loop internal drains to prevent mosquito bleeding. This shall be performed at least once every 3 days. This is included in the Cleaning Section of the maintenance procedures.

Std 08: Environment

Water retention (leak) test to be performed **annually** to check for any leak from the secondary containment in storage area and Oil drum containment pallets. The storage area containment valve is normally kept closed and opened only when rain water needs to be drained. The valve status needs to be checked regularly. Record the data of test as a part of the maintenance register.

- Secondary containment area (Storage tank containment area, Flow Loop sump) and oil containment pallets. **Annual** integrity test is to be performed. Report to be captured in Quest. Documented in SWTC-Chemicals and Fluid Management Procedure (SWTC-CFMP).
- Spill response drill (at least **1 per year**). Refer to Spill Preparedness Response Procedure.
- Clearing of sump is required whenever the sump is full of waste discharge.

Std 11: Employee and Asset Security

The physical access control system is maintained under the Center Facility Maintenance Program which includes a **bi-annual** servicing and maintenance contract. The list of authorized personnel granted access to flow loop control room is under the control of Flow Loop area responsible manager. The posting of authorized personnel shall be made available at the entrance of the flow loop. The list shall be reviewed on a quarterly basis to ensure strict control on flow loop access.

Std 13: Mechanical Lifting

Flow loop has one mechanical lifter which is used for lifting job as and when required. The lifting certificate is posted on the lifter and shall be renewed before expiry. All lifting equipment including lifting accessories like shackles, sling shall be checked for any physical damage and safe condition before use and load tested annually. The lifting certificate shall be maintained in the PLQS register for records.

- Lifting certificate/**Annual** Certification required. All lifting equipment and devices needs to have valid MOM lifting certificate.
- Documented Lifting Plan for Standard Lifting Operations. Non-standard lift will require attention of Lifting Supervisor

- REMS Additional Mechanical Lifting Controls

Std 14: Pressure

- REMS Pressure Operations Guideline (SLB-QHSE-S014-EMS01)
- Area access requirement. Restricted access and HSE briefing for all others.

Std 16: Fire Prevention and Mitigation

- Perform **2 drills annually** as part of Center Emergency Response drill.
- Fire Protection System servicing. This is maintained as part of Center Facility Maintenance Program under responsibility of Facility Maintenance.
- Fire Safety Manager performs a **monthly** site inspection.
- FM global performs **annual** site inspection covering mainly fire protection system.

Std 17: Injury Prevention

- No specific maintenance required. Strictly follow SIPP while working in FL.

Std 18: Radiation

- REMS Radiation Safety Standard (SLB-QHSE-S018-EMS01)
- REMS Radiation Source Management Standard (SLB-QHSE-S018-EMS02)
- REMS Transportation of Radioactive Material Standard (SLB-QHSE-S018-EMS03)

Std 20: Hazard Analysis and Risk Control

- Define routine activities and HARC completed for all routine activities. All routine HARCs are reviewed on an **annual** basis. LPT will support the tracking on the HARC status.
- Non-routine should have HARC completed and Start Work permit for all contractor involved works.
- Use Stand back 5 x 5 every time performing a task.
- Start Work Briefing.

Std 23: DROPS

Flow Loop has many inaccessible equipment which may need to be operated for operation or maintenance work. Safety measures needs to be considered while working at height more than 2 meters and using ladder wherever possible. The safety harness should be wear in case person is working at height more than 2 meters (working at Height for the gas separator platform).

EMS Electrical standard REMS Electrical Standard (EMS-HSE-S003)

Flow Loop comprises of various pumps which are operated at 415 V, 50 Hz. The max. power rating of the VFD is 315 W. The total electrical load in the process plant is around 2 MVA. The power distribution is certified as per Singapore Power Authorities and have protection devices in main switchboard. In downstream, the motors (Oil, Water and Gas pumps) have circuit breakers on VFD incoming. The small rating motors (Vacuum Pump, Transfer Pump) are powered through starter in PLC 4 Cabinet. All the power cable connections to be visually checked for any spark or burn on the terminals **bi-annually** and replaced if required.

NOTE: The incoming breaker should be always disconnected and locked out before carrying out any maintenance on Electrical System.

- Annual inspection of switchboard
- Thermo-scan (as applicable)
- Inspection of electrical tool/Periodically
- Earth leakage test. Grounding report. Recommended **annually**.

5 PREVENTIVE MAINTENANCE

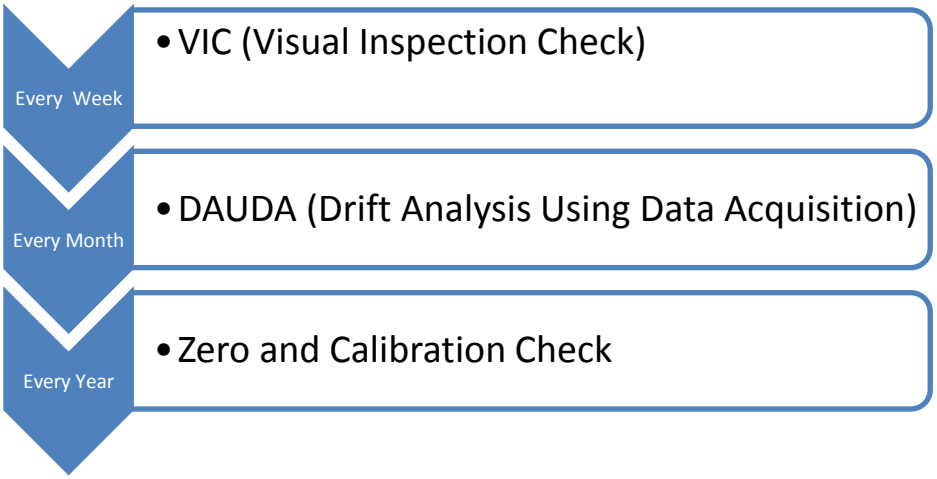
As Flow Loop facility is used for qualification of MPFM's, it is highly important to maintain the accuracy and operability of reference equipment and meters. The objective of Preventive Maintenance is to minimise failure and increase MTTF of the equipment in the long term usage of the Flow Loop.

The program involves 3 levels of inspection and tests.

1. VIC (Visual Inspection Check)
2. DAUDA (Drift Analysis using Data Acquisition)
3. Zero and Calibration Check

Term	Definition
VIC (Visual Inspection Check)	This is the 1st step of preventive maintenance and it involves checking each device individually. This level covers the identification of any mechanical damage or worn out parts and the reading from the transmitter.
DAUDA (Drift Analysis Using Data Acquisition)	In this step, the FL labview data acquisition system is used for checking the values transmitted by the device and compared with the reading from the other device in the same ambient conditions.
Zero and Calibration Check	This is the next step of troubleshooting the problem if the error is not identified from DAUDA. In this step, the device is tested for zero reading and other calibration parameters check. This step should clarify the issue at the sensor level or transmitter level and decision of recalibration is taken. The device is sent for recalibration if any issue is found at this stage or it has completed the calibration period as mentioned in Maintenance Yearly Calendar.

As preventive maintenance is to check overall health of the instrument/system, it covers physical as well as verification of transmitted data. Preventive Maintenance Plan for the devices should follow the below sequence:



DAUDA for Pressure and Temp. Transmitter:

This is the procedure to check any drift in the reading of the instruments for the same ambient conditions. We do it by recording the value of all the pressure and temp. transmitter reading on the database (Citadel) and comparing it with the transmitter readings of the previous month.

As Flow Loop is a closed system, the pressure and temp. readings are always in some ratio of one another. One of the meter is taken as the reference meter and the other transmitter readings are calculated as a ratio with the reference meter. The sheet "FL_InstrumentDriftCheck.xlsx" is used for comparing the readings and record the deviation.

The ratio of various transmitters should somewhat remain same and if some drift is noticed in any one of the transmitter, that particular transmitter is taken for further analysis (Zero and Calibration Check). This procedure helps to identify any major issue in the reading of the transmitters.

NOTE1: The reading of pressure and temp. should be taken in stable condition (i.e. FL not running) and at similar pressure and temperature.
NOTE2: On the liquid lines, the pressure readings will deviate due from one another due to hydrostatic pressure. This should be factored in while doing the analysis.

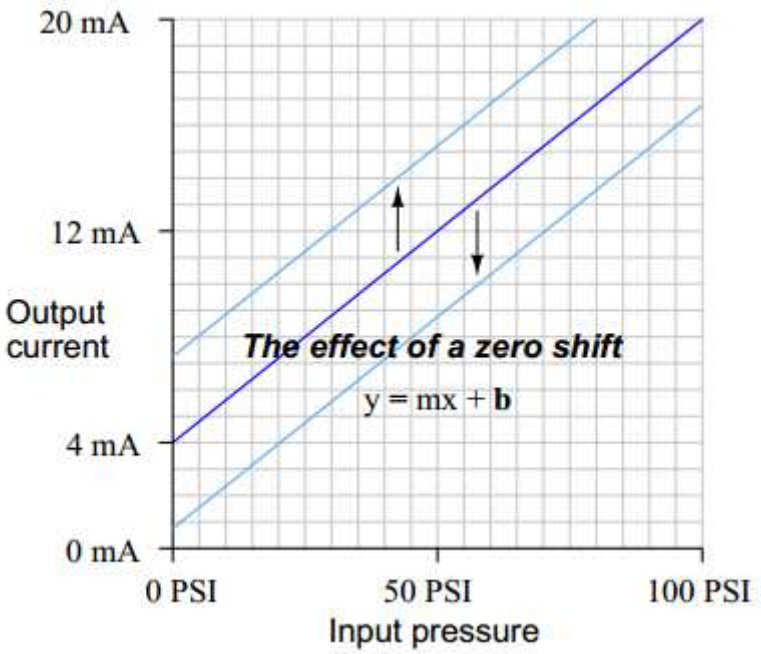
- **DAUDA for Flow Meters:**

This should be carried out as per the Quality Indicators check as mentioned in the document SWTC Flow Loop - Reference Measurement & Calculations – revAA.

6 METROLOGY CALIBRATION

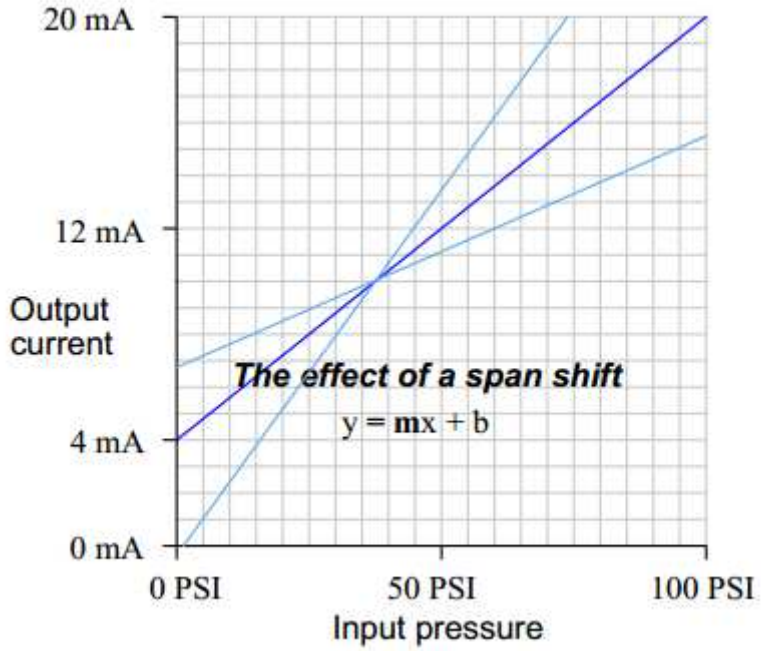
The efficient identification and correction of instrument calibration errors is an important function for instrument technicians. For some technicians – particularly those working in industries where calibration accuracy is mandated by law – the task of routine calibration consumes most of their working time. For other technicians calibration may be an occasional task, but nevertheless these technicians must be able to quickly diagnose calibration errors when they cause problems in instrumented systems. This section describes common instrument calibration errors and the procedures by which those errors may be detected and corrected.

Typical calibration errors:
Recall that the slope-intercept form of a linear equation describes the response of any linear instrument:
y = mx + b
Where,
y = Output
m = Span adjustment
x = Input
b = Zero adjustment
A zero shift calibration error shifts the function vertically on the graph, which is equivalent to altering the value of b in the slope-intercept equation. This error affects all calibration points equally, creating the same percentage of error across the entire range. Using the same example of a pressure transmitter with 0 to 100 PSI input range and 4 to 20 mA output range:

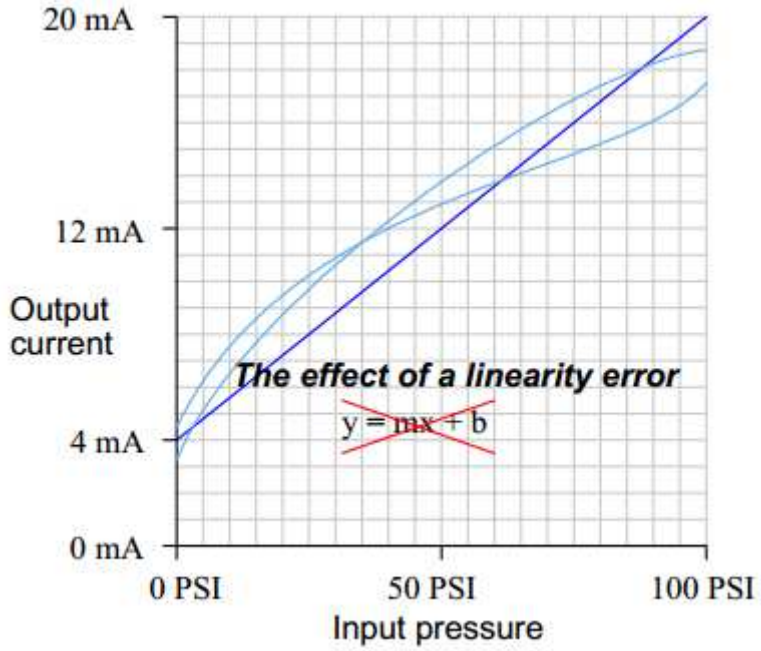


If a transmitter suffers from a zero calibration error, that error may be corrected by carefully moving the “zero” adjustment until the response is ideal, essentially altering the value of b in the linear equation.

A span shift calibration error shifts the slope of the function, which is equivalent to altering the value of m in the slope-intercept equation. This error’s effect is unequal at different points throughout the range:



If a transmitter suffers from a span calibration error, that error may be corrected by carefully moving the "span" adjustment until the response is ideal, essentially altering the value of m in the linear equation. A linearity calibration error causes the instrument's response function to no longer be a straight line. This type of error does not directly relate to a shift in either zero (b) or span (m) because the slope-intercept equation only describes straight lines:



Some instruments provide means to adjust the linearity of their response, in which case this adjustment needs to be carefully altered. The behaviour of a linearity adjustment is unique to each model of instrument, and so you must consult the manufacturer's documentation for details on how and why the linearity adjustment works. If an instrument does not provide a linearity adjustment, the best you can do for this type of problem is "split the error" between high and low extremes, so the maximum absolute error at any point in the range is minimized.

6.1 Flow Loop Instruments Calibration

The Flow Loop instruments are calibrated periodically as described in the preventive maintenance and functional maintenance procedure. The calibration cycle is based on the usage and criticality of the instrument. DAUDA and quality indicators (defined in Reference Measurement & Calculations document) helps to extend the calibration period and thus increase the efficiency and effectiveness of the process. The periodic calibration is also required for all the pressure equipment, lifting equipment and floor crane. Refer the Appendixes for detailed calibration check procedures of devices in Flow Loop. The calibration of critical instruments and lifting devices is tracked in PLQS.

6.2 Certificate Validity

Considering the criticality of the process, it is important to keep all the calibrations and certifications up to date. All the critical equipment in Flow loop are certified periodically and reports are kept in Schlumberger internal software PLQS. Refer http://plqs.slb.com/bpm/workspace/faces/jsf/worklist/worklist.jspx?_afrLoop=7360258944740000&_afrWindowMode=0&_adf.ctrl-state=qfmgpjb30_4 for details of the equipment and instruments listed in PLQS. PLQS helps to trigger the reminder of recalibration and certifications for the user automatically. Once the equipment is recalibrated, the details need to be updated in the system with the report.

Manage IMT Equipment

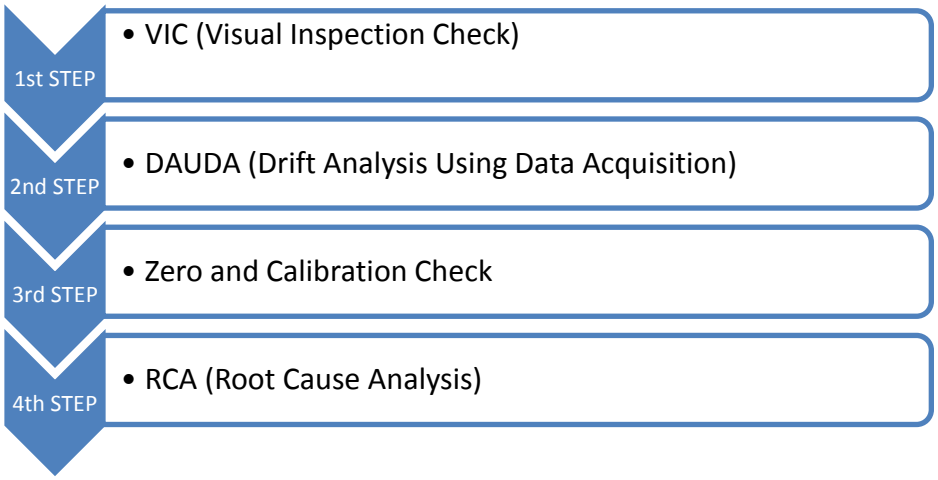
View ▾ | Create Multiple New IMTE | Create New IMTE | Edit / Transfer | Copy | Detach

		Flow Loop						
Business Unit	Equipment ID	IMT Work Center	Equipment Type	Manufacturer	Model	Serial Number	Equipment Status	Next Calib Date
SWTC	544HJ	Flow Loop	Pressure Gauge	E+H		K6018121128	Available for Use	29-Jun-20
SWTC	92PRT	Flow Loop	Flow Meter	Micromotion		13082787/33091355	Available for Use	15-Aug-2
SWTC	RSXMT	Flow Loop	Flow Meter	Micromotion		12103625/330005	Available for Use	07-Aug-2
SWTC	TRTWF	Flow Loop	Flow Meter	Micromotion		12103821/33088070	Available for Use	07-Aug-2
SWTC	GBW9S	Flow Loop	Flow Meter	Micromotion		13082785/33088872	Available for Use	15-Aug-2
SWTC	JHZWQ	Flow Loop	Flow Meter	Micromotion		12103895/33102537	Available for Use	15-Aug-2
SWTC	ZCFWJ	Flow Loop	Flow Meter	Micromotion		13082347/33102513	Available for Use	18-Aug-2
SWTC	P2DNK	Flow Loop	Flow Meter	Micromotion		12104192/33102251	Available for Use	15-Aug-2
SWTC	VGKKL	Flow Loop	Flow Meter	Emerson		03173813	Available for Use	15-Jul-20
SWTC	RLK2H	Flow Loop	Flow Meter	Emerson		06133894	Available for Use	14-Aug-2
SWTC	C3CY9	Flow Loop	Temperature Sensor	E+H		K600EB97152	Available for Use	08-Jul-20
SWTC	Z5ZZ4	Flow Loop	Flow Meter	Emerson		06133891	Available for Use	19-Aug-2
SWTC	2VS9Y	Flow Loop	Pressure Gauge	E+H		K6018021128	Available for Use	29-Jun-20
SWTC	YCNXN	Flow Loop	Temperature Sensor	E+H		K600EA97152	Available for Use	08-Jul-20
SWTC	YXRWK	Flow Loop	Lifting Device	Genie		SLA14-54210	Available for Use	19-Dec-20

Fig2 : List of critical equipment in PLQS

7 FUNCTIONAL MAINTENANCE

The regular checks on the instruments and equipment is done as a part of Preventive Maintenance. Functional Maintenance is a disruptive check on the instrument if any abnormality is noticed in the reading of the instrument during normal operation or during the Preventive Maintenance Checks.
Thus, functional maintenance is an enhancement of Preventive maintenance procedure. It has same initial steps as the preventive maintenance procedure but in addition we have further checks to resolve the issue.



Functional Maintenance Plan for the devices should follow the above sequence. The levels of inspections should be based on the result of the previous level.

The 4th level of check is RCA

RCA (Root Cause Analysis)	**After verifying the issue in the device by going through 1st three steps, fault is identified and decision is made here for changing settings in-house, sending the device for recalibration, asking the supplier for replacement of faulty parts or changing with spare units.**

The maintenance procedure for individual instrument should cover both preventive and functional maintenance as the procedure is same and difference is mainly in the timing of use of the procedure. The procedures of maintenance for each type of instrument are as listed in Appendix 2 to 24.

8 SOFTWARE

Flow Loop process is a semi-automatic system which is mainly operated from the server in the control room. Various control technologies and communication protocols have been used to run the process and capture all the major parameters by a click of a button.

The various software used in Flow Loop are:

1. PLC software designed as per IEC 61131-3 standard
2. HMI software designed on labview
3. VFD parameter files
4. Cloud based software on SCADA+

It is important to archive the latest versions of software as a backup. This will help to bring the system up in case the program is erased from the memory of processors.

8.1 Revision & Backup Control

Flow loop process software upgrades are strictly controlled by keeping all the changes documented in the release notes issued with each updated version of the software.

- The latest PLC software with all the previous revisions and respective release notes is kept in the following location in teamspace in the “SoftwareBackup” folder”: https://slb001.sharepoint.com/sites/SWTC/SWTC%20Flowloop/Maintenance%20Procedures/Forms/AllItems.aspx?id=%2Fsites%2FSWTC%2FSWTC%20Flowloop%2FMaintenance%20Procedures%2FSoftwareBackup
- The latest HMI software with all the previous revisions and respective release notes is kept in the following location teamspace in the “SoftwareBackup” folder”: https://slb001.sharepoint.com/sites/SWTC/SWTC%20Flowloop/Maintenance%20Procedures/Forms/AllItems.aspx?id=%2Fsites%2FSWTC%2FSWTC%20Flowloop%2FMaintenance%20Procedures%2FSoftwareBackup
- SCADA+ software is upgraded over the cloud from the supplier RPM.
- The version control is also tracked in the Quest Report 20160607100133.
- The other important backup we should have is the test data which we acquire from the data acquisition system. The data files are stored in the Flow Loop system daily. The data from local server is archived into the shared folder regularly.

8.2 PLC Program Check

PLC code is the brain of the Flow Loop process. The various safety conditions, critical alarms, starting and stopping process of the pumps are defined in the PLC Program. Any kind of fault in PLC hardware or software bug can cause process shutdown or other kind of unexpected behaviour in the operation of the loop. It is necessary to check the various software blocks if any new version is deployed or software is updated. This should be done for every new version release of **annually** whichever is earlier.

9 FACILITY MAINTENANCE

Oil Tanks

- Requirements by Standard S008, Documented in SWTC-Chemicals and Fluid Management Procedure (SWTC-CFMP)
- **5 yearly** NDT integrity test
- **5 yearly** Hydrostatic Test for bulk tanks

Air-conditioning

- **Monthly** Maintenance Program
- Part of main facility contract with service provider
- Washing filter

Cameras

- Part of main facility contract with ICD
- **Bi-Annual** Service Maintenance (Camera inspection, cleaning, database backup and system testing)

Electrical Panel (FL switchboard)

- **Annual** Functional Trip Test for circuit
- **Annual** Earth leakage test. Grounding report.

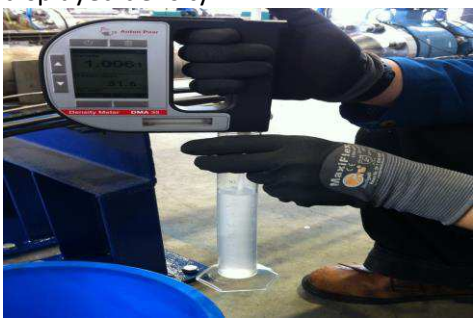
Fire System

- Part of main facility contract with HART
- **Monthly** testing of Fire Alarm,
- **Weekly** running of Fire Pump,
- Visual check of Fire Extinguisher
- **Annual** check of Fire Extinguisher

10 OPERATION MAINTENANCE

The Flow Loop process is a complex operation involving various types of equipment. Some of the steps as listed below should be carried out periodically to keep the process safe and healthy.

Task	Procedure	Frequency
Visual inspection for any possible leak from the Flow Loop	1. Check for any droplets of liquid on the floor. Therefore, it is important to keep the area dry. 2. Monitor the Pressure inside the loop. It should not drop every day. 3. Soap test after rig up and rig down.	Daily
Open Bleed Valve on flanges	Bleed off the vent valves on the flexible hose and test lines (Testing Sections) isolated sections to prevent pressure build-up inside the isolated section.	Weekly
Flanges tightness check Sections to be covered are: 1. Liquid Section 2. Compressor Section 3. Mixing and Testing Section 4. Storage Area	Check the tightness of the nuts on pipe flanges and instruments visually. See the marking on the nuts of flange should be inline with the marking on the flange.  **Image 8**: Marking on the flanges	Monthly

Check for any internal leakage through the Valves (Test line). 1. Liquid Section 2. Compressor Section 3. Mixing and Testing Section 4. Storage Area	Procedure varies depending on the type of valve and the location of the Valve. It is defined in details in the Appendix-21.	Annually
Check the density of Oil and Water using handheld density meter	The density is measured by taking sample from MV 1317 (for water) and MV 1318 (for Oil). The measured values should be entered into the SCADA "Densities" page to check for any deviation from the Coriolis meter displayed density.  **Image 9**: Checking density using Densitometer	Starting of every new matrix, after maintenance or Quarterly
Check if there is any liquid being collected in the buffer tank	This is to check for any carry over on the gas line or if the liquid is flowing back from compressor to the Buffer Tank. Also, it helps to detect for any bacteria developing inside the loop.	Weekly
The strainer (STR 1606) at the transfer pump inlet to be checked for any blockage or deposition	The strainer is used on the inlet line when we transfer liquid into the Flow Loop. It should be cleaned periodically.	Bi-annually

10.1 Scaling Control

The use of brine and different temperature conditions in Flow Loop may give rise to scaling being formed inside the pipelines. For now, we monitor the formation of scale by viewing through the sight glass on the test lines .The use of inhibitors for prevention of scale is in discussion.

10.2 Rust Control

The hot and humid climate in Singapore is ideal for the corrosion to develop on the metal surface. To prevent the corrosion in the Flow Loop, all the equipment used are of stainless steel other than the body

of the compressor. Some of the areas where it has been found that corrosion may develop and needs to be cleaned using anti-rust are:

1. Nuts of the manual valve handles
2. Welding joints of the skids, piping and equipment
3. Locks on the valves
4. Throttling valves on the nitrogen pallet manifold.

The frequency of checking Rust is defined in Section 2 under chemical cleaning and if Rust is found on any part, cleaning action should be taken. The solution used for cleaning stainless steel is acid, supports should be cleaned using brush and blue Paint, any other metallic part should be cleaned using anti rust.

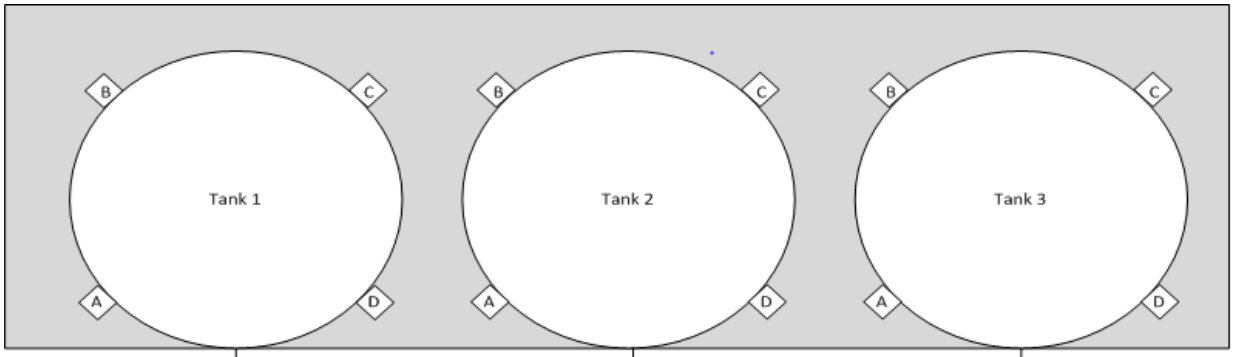
BEFORE	AFTER
	

Image10: Cleaned Rust on the joints of the skid

10.3 Storage Tank Anchoring

The 3 storage tanks are resting on the bitumen at the base of the tanks to remove to stabilize the uneven base of the tanks firmly on the ground. The variation in the base height from the raised floor is to be taken **bi-annually** to check for any deviation.

The screen shot below shows the various readings taken initially to check for the stability of the tanks. As the bitumen is solidified in the course of time. We saw there is not much variation in the support dimensions. Therefore, the sides of the tank base has been cemented. Now, we just need to take readings as shown in the below sheet **bi-annually** to track the stability of the tanks. The record sheet "FL_Tanks_Settlement.xlsx" contains the data for the deviation and is updated after check.



	Tank 1				Tank 2				Tank 3			
Date	A	B	C	D	A	B	C	D	A	B	C	D
4/24/2015	58	87	76	62	63	64	62	57	35	84	86	37
4/29/2015	40	80	70	40	52	62	57	44	45	69	68	42
5/4/2015	39	76	68	41	49	61	56	44	39	69	69	36
5/6/2015	39	74	66	41	48	59	54	44	38	67	67	35
5/11/2015	38	71	64	40	46	57	53	43	36	66	66	34
5/13/2015	37	69	60	40	46	55	51	41	36	65	64	34
5/18/2015	37	67	59	40	46	53	50	41	35	63	63	33
5/20/2015	37	69	61	40	47	53	50	41	35	65	65	34
5/25/2015	37	99	92	40	48	58	52	41	37	99	96	34
6/11/2015	37	107	99	40	48	64	60	42	45	118	156	34
6/15/2015	37	71	62	40	47	55	52	42	35	67	67	33
6/23/2015	**37**	**68**	**59**	**40**	**46**	**52**	**49**	**41**	**34**	**65**	**65**	**33**
4/14/2016	41	55	42	41	45	43	36	46	37	46	48	43
minus 12mm rubber	25	56	47	28	34	40	37	29	22	53	53	21
minus 30mm plate	-5	26	17	-2	4	10	7	-1	-8	23	23	-9
number of 5mm plates	-1	5	3	0	0	2	1	0	-1	4	4	-1
Jack up?	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes
Plate min	21	mm										
Plate max	37	mm										

Fig3: Storage Tanks Stability Check sheet

10.4 Bacteria Control

It has been noticed that some bacteria is developing at the Oil-Water interface of the liquid we have in the Flow Loop. We should monitor the cleanliness of liquid inside the FL by taking samples **Quarterly**. The sample should be taken from MV 1317 (for water) and MV 1318 (for Oil) or from the buffer tank (If there is liquid deposited in buffer tank).It is important to flush the test lines at end of testing every day.

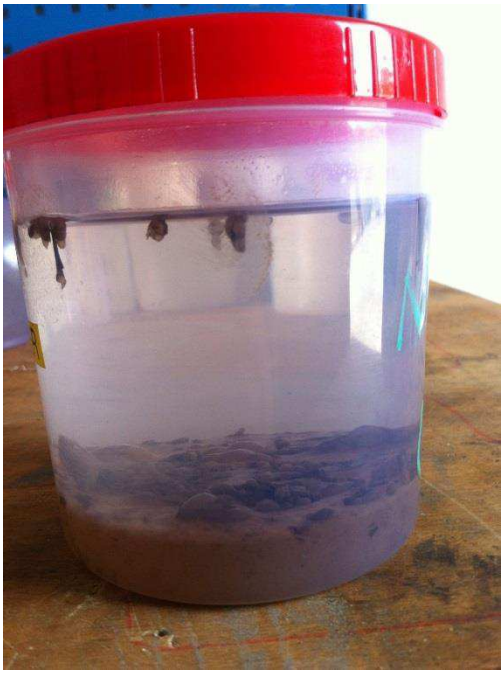


Image 11: Bacteria on the water oil interface

10.5 Zeroing of Coriolis meters at different pressures

SWTC Flow Loop can be operated at different pressures (3-30 Bar). As the accuracy of Coriolis meters is affected by change in pressure, we have pressure compensation enabled by default. As a precautionary measure, it is required to do the **zero check** of all the Coriolis meters when the pressure is changed in the Flow Loop

10.6 Documentation Update

SWTC Flow Loop documentation is revised regularly based on any updates in the system process or any other modification. The documentation should be reviewed at least **once in a year** for any changes required.

11 References

Consult the latest valid version of each document referenced.

11.1 Normative References

Title

1. Lessons In Industrial Instrumentation c 2008-2015 by Tony R.

11.2 Informative References

	Title	Document Number
1.	Reference Measurement & Calculations	DMS# 102923814
2.	FL_Maint_Yearly.xlsx	DMS# 102942672
3.	FL_MaintCalender_Mnthly.xlsx	
4.	FL_InstrumentDriftCheck.xlsx	
5.	FL_Tanks_Settlement.xlsx	
6.	Leak Test Procedure	DMS# 102683162

A <Maintenance Procedure Check sheets>

The check sheets shown below are used as a procedure for maintenance of the specific instrument/area as and when required. The information about the frequency of usage of check sheet is specified in above sections. The check sheet should be saved as report in maintenance register or PLQS as and when maintenance is completed.

A-1 FL_CLEANING CALENDAR TEMPLATE

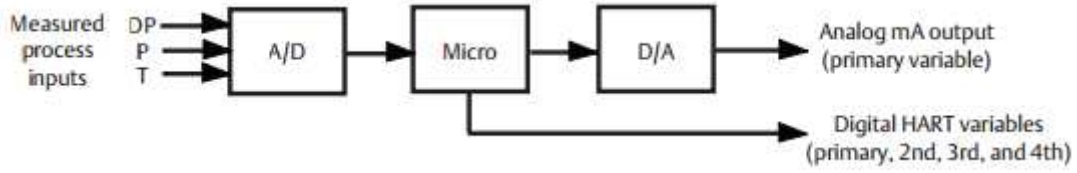
Month ..... **Year** .....

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

A-2 ORIFICE FLOW METER: 3051SMV

In any DP flow system, there are three sources of flow error, DP transmitter errors, pressure and temperature variation and primary element errors. Users need to minimize all three sources of these errors for best accuracy and repeatability

The transmitter data flow is as shown below:



If any discrepancy in the reading of the flowmeter is found and needs to be corrected, we should sequentially check the reading of meter from right to left i.e. starting with D/A towards A/D and lastly the sensor. It is a way to isolate the problem in the different sections of the instrument.

Preventive Maintenance:

This should be carried out every month.

- **Visual Check:**

1. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
2. Check the impulse lines and the process seal are connected properly.
3. Check the electrical cable connection is proper and the gland is tightened properly.
4. Check for any alarm on the LCD screen.

- **DAUDA:**

The reading of the meter should be verified with the Coriolis meters in the line (Every **2 months**). Remember to check the flow at the meter conditions (P,T). The accuracy of the meter is 0.75 % of the flow rate.

- **Zero and Calibration Check:**

This involves further troubleshooting of the instrument if we suspect any error in the DAUDA stage.

Check the zero of the instrument by keeping the pressure on Inlet and Outlet ports same or isolating from the process and opening the equalization valve on the manifold.

Follow the zero process using manifold as mentioned in Section 3: Installation of reference manual (00809-0100-4803, Rev EB), page 85. The zero trim for the Orifice meter can be done using AMS, Engineering Assistant or Handheld device by Emerson. Refer to Section 4: Operation and Maintenance of reference manual (00809-0100-4803, Rev EB) for the procedures.

NOTE: The transmitter must be within five percent or less of the maximum span of true zero (zero-based) in order to calibrate with zero trim function.

NOTE: Record As_Found configuration values of the instrument before proceeding with any kind of modification/calibration of the meter.

Functional Check:

If some error is found during normal operation cycle, the troubleshooting involves the procedure mentioned in preventive maintenance section and further checks can be done for fault diagnostics.

Fault Diagnostics:

Fault troubleshooting is explained in detail in Section 5 of the Reference Manual (00809-0100-4803, Rev EB).

Reference:

1. Reference Manual (00809-0100-4803, Rev EB)
2. PO Number: SIP00127
3. Supplier Contact Person : Michelle Lee
   Email ID: michelle.lee@emerson.com
   Phone Number: 6770 8109

A-3 VORTEX FLOW METER: Rosemount 8800D

The Rosemount 8800D Vortex Flowmeter consists of a meter body and transmitter, and measures volumetric flow rate by detecting the vortices created by a fluid passing by the shedder bar. The meter body is installed in-line with process piping. A sensor is located at the end of the shedder bar and creates an alternating sine wave due to the passing vortices. The transmitter measures the frequency of the sine waves and converts it into a flowrate.

Preventive Maintenance:
This should be carried out every month.

- **Visual Check:**

1. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
2. Check the grounding of the meter is connected properly to the site grounding.
3. Check for any alarm on the LOI (Local Operator Interface). Refer to the diagnostics messages mentioned in the Reference Manual (00809-0100-4004, Rev DA, Section 5.3) for the list of Error Messages and their corrective action.
4. Check the electrical cable connection is proper and the gland is tightened properly.
5. Check the process parameters (Density Ratio, K-factor, Flange type, Mating Pipe ID etc.) are same as configured during last calibration. Refer figure 2.1, Installation Flowchart in Reference Manual for details.

- **DAUDA:**

The reading of the meter should be verified with the Coriolis meters in the line (Every 2 months) in the overlapping range. The accuracy of the meter is 0.65 % of the flow rate (at higher than 12 m3/hr).

- **Zero and Calibration Check**:

This involves further troubleshooting of the instrument if we suspect any error in the DAUDA stage. Check the zero of the instrument by keeping the lines full of liquid and closing the valves on both the sides of the meter. Check for reading of the meter at zero flow. If an output error at zero flow is still detected, it can be eliminated by adjusting the low flow cutoff, trigger level, or low-pass filter.
If the error still exists then further checks are required on the instrument.

Functional Check:
This is the next step for testing in case the error still persists. The checks required in this step are:

1. Loop Test
2. Flow Simulation

Fault Diagnostics:
Fault troubleshooting is explained in detail in Section 5 of the Reference Manual (00809-0100-4004, Rev DA).

Reference:

1. Reference Manual (00809-0100-4004, Rev DA)
2. PO Number: SIP00125
3. Supplier Contact Person : Kendrick Tan
   Email ID: Kendrick.tan@emerson.com
   Phone Number: 6770 8109

A-4 EM FLOW METER: Rosemount 8732

The Rosemount® 8700 Series Magnetic Flowmeter System consists of a sensor and transmitter, and measures volumetric flow rate by detecting the velocity of a conductive liquid that passes through a magnetic field.
The meter we have in Flow Loop is a basic meter with no features of self-diagnostics, 8714i diagnostics.

Preventive Maintenance:
This should be carried out every month.

- **Visual Check:**

1. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
2. Check the grounding of the meter is connected properly to the site grounding through the least resistance path.
3. Check for any alarm on the LOI (Local Operator Interface). Refer to the diagnostics messages mentioned in the Reference Manual (00809-0100-4662, Rev DA, Table 6.1) for the list of Error Messages and their corrective action.
4. Check the electrical cable connection is proper and the gland is tightened properly.

- **DAUDA:**

The reading of the meter should be verified with the Coriolis meters in the line (Every 2 months) in the overlapping range. The accuracy of the meter is 0.25 % of the flow rate (at higher than 15 m3/hr).

- **Zero and Calibration Check:**

This involves further troubleshooting of the instrument if we suspect any error in the DAUDA stage. Check the zero of the instrument by keeping the lines full of liquid and closing the valves on both the sides of the meter. Check for reading of the meter at zero flow. If any error is found at zero flow, proceed to perform zero trim for the meter. Refer the Reference Manual (00809-0100-4662, Rev DA) for the procedure.
If the error still exists then further checks are required on the sensor.

Functional Check:

Transmitter
Note: Power the instrument before checking the sensor

1. Verify that the correct sensor calibration number is entered in the transmitter. The calibration number is listed on the sensor nameplate.
2. Verify that the correct sensor line size is entered in the transmitter. The line size value is listed on the sensor nameplate.
3. Verify that the analog range of the transmitter matches the analog range in the control system.
4. Verify that the forced analog output and forced pulse output of the transmitter produces the correct output at the control system.

Sensor

Note: Remove power from the instrument before checking the sensor

1. Ensure that the electrodes remain covered by process fluid.
2. Ensure that the grounding straps on the sensor are connected to grounding rings, lining protectors, or the adjacent pipe flanges. Improper grounding will cause erratic operation of the system.
3. To measure the sensor resistance and verify the sensor, refer to Table 6-6. Sensor Test of Reference Manual (00809-0100-4662, Rev DA)

Fault Diagnostics:

Fault troubleshooting is explained in detail in Section 6 of the Reference Manual (00809-0100-4662, Rev DA).

Reference:

1. Reference Manual (00809-0100-4662, Rev DA)
2. PO Number: SIP00125
3. Supplier Contact Person : Kendrick Tan
   Email ID: Kendrick.tan@emerson.com
   Phone Number: 6770 8109

A-5 **dP METER: PMD55**

Note: Reference accuracy is 0.1% as per the vendor's document. The reference accuracy comprises the non-linearity according to limit point setting, hysteresis and non-reproducibility as per IEC 60770. Total error of the instrument is in the range as below:

Total Error

Measuring cell	% of URL / 1 year	% of URL / 5 years
10 mbar (0.15 psi) 30 mbar (0.45 psi)	±0.97	±0.95
100 mbar (1.5 psi)	±0.26	±0.39
500 mbar (7.5 psi) 1 bar (15 psi) 3 bar (45 psi)	±0.14	±0.18
16 bar (240 psi)	±0.17	±0.20
40 bar (600 psi)	±0.14	±0.18

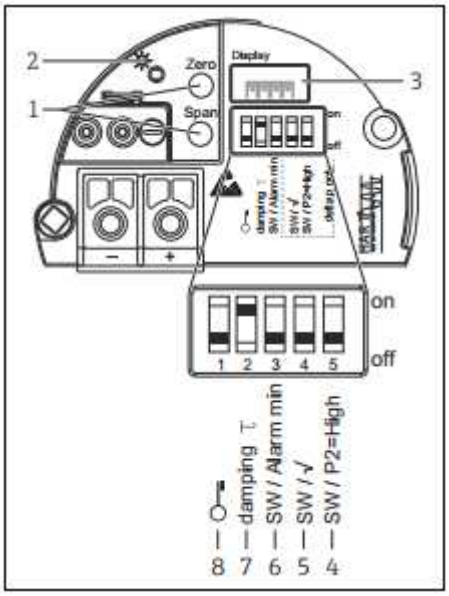
Preventive Maintenance:
This should be carried out every 2 months.

1. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
2. Check the impulse lines and the process seal are connected properly.
3. Check the electrical cable connection is proper and the gland is tightened properly.
4. Check the zero of the instrument by keeping the pressure on P1 and P2 ports same or isolating from the process and opening the equalization valve on the manifold.

Functional Check:
This involves further troubleshooting of the instrument if error in the zero reading is found.

Zero Trim

Check the zero of the instrument by keeping the pressure on Inlet and Outlet ports same or isolating from the process and opening the equalization valve on the manifold. If any discrepancy is found, zero of the transmitter can be done by pressing the Zero button on the electronic insert.



NOTE: Record As_Found configuration values of the instrument before proceeding with any kind of modification/calibration of the meter.

Fault Diagnostics:
The diagnosis option on local display can help to troubleshoot for any issues with the transmitter

CALIBRATION:

Reference:

1. Technical Information Deltabar M PMD55 (TI00434P/00/EN/19.16)
2. PO Number: 10308941
3. Supplier Contact Person : JK Lim
   Email ID: loh.meefoo@sg.endress.com
   Phone Number: 66522721

A-6 ACTUATED VALVE: TOPWORX

No major maintenance is required.

Preventive Maintenance:
This should be carried out every 3 month.

1. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
2. Inspect all O-rings for wear and replace as necessary.
3. Check the electrical cable connection is proper and the gland is tightened properly.
4. Switch setting can be checked periodically.

Functional Check:
This involves further troubleshooting of the instrument if the command and feedback is not working as required.

1. Check for the switch continuity at the actuator terminals.
2. Replace the switch if found faulty.

Reference Documents

1. Valvetop™ TV-Series Valve Controllers Installation, Operation & Maintenance Manual

A-7 CONTROL VALVE: DVC 6200

The valves we have used are Class VI with DVC6200 digital valve controller. The diagnostic capability of the DVC6200, predictive maintenance is available through the use of ValveLink software.

Preventive Maintenance:

This should be carried out every month.

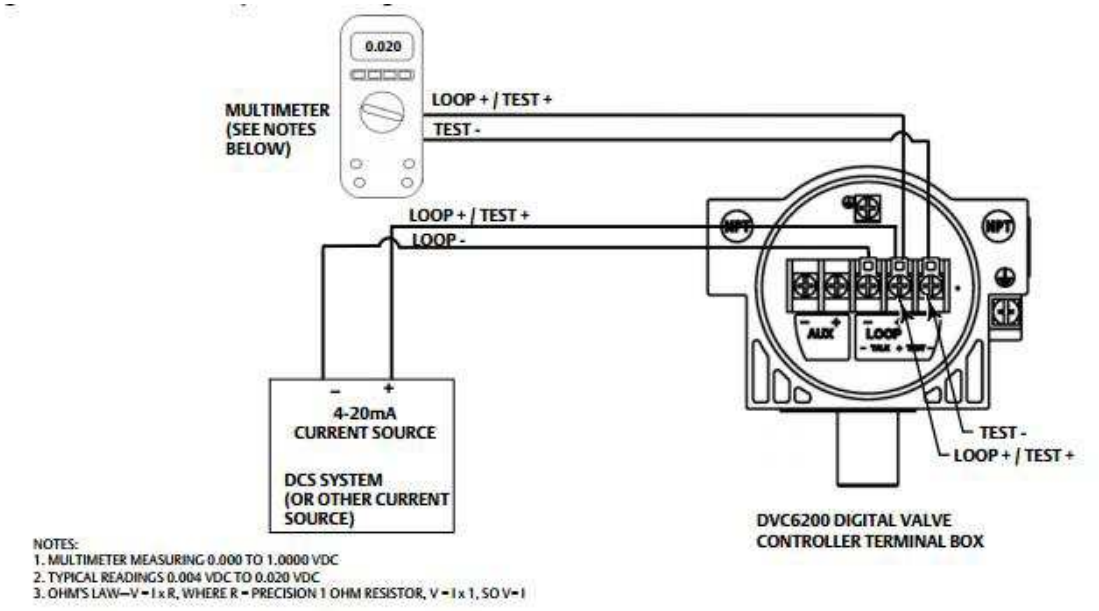
1. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
2. It is recommended that the vent (key 52) be inspected to ensure it is fully open. If the vent appears to be clogged, it can be removed, cleaned and replaced. Lightly brush the exterior of the vent to remove contaminants and run a mild water/detergent solution through the vent to ensure it is fully open. Allow the vent to dry before reinstalling.
3. Inspect all O-rings for wear and replace as necessary.
4. Check the electrical cable connection is proper and the gland is tightened properly.
5. Check the valve goes to the fail-safe condition on power or air shut down.
6. Check the air supply is set at 4 Bar and the air supplied is clean and dry.

Functional Check:

This involves further troubleshooting of the instrument using multimeter, HART compatible device or Valvelink software.

Troubleshooting:

The loop current check can be performed by using the multimeter as shown below:



1. Measure the voltage across the “Loop -” and Loop +” terminal box screws when the commanded current is 4.0 mA and 20.0 mA: _____V @ 4.0 mA _____V @ 20.0 mA. (These values should be around 9.6 V @ 4.0 mA and 10.3 V @ 20 mA).

2. The reading at the test terminals is proportional to the loop current [0.004 V = 0.004 A (4 MA)] mA of loop current). Refer to Specifications, table 1-2, to determine if the current is sufficient.

Fault Diagnostics:
For further troubleshooting on the device, we need to check various conditions as mentioned in Table 7-3: Section7: Instruction Manual.

CALIBRATION:
This can be done by connecting the Field Communicator to the valve. If a new controller is ordered, calibration of the controller with valve may be done. After mounting on an actuator, perform the initial setup then calibrate travel by selecting Configure > Calibrate > Travel Calibration > Auto Calibration.
For manual calibrations, follow the procedure as mentioned in Section 5 of the Instruction Manual.

Reference:

1. Instruction Manual - D103409X012
2. PO Number: 10315724
3. Supplier Contact Person : Nicole Foo
   Email ID: Nicole.foo@emerson.com
   Phone Number: 67708109

A-8 CAPACITANCE SWITCH: Electronic insert FEI52 (DC PNP)

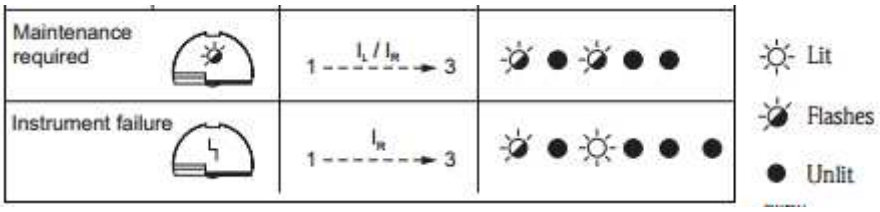
Preventive Maintenance:
This should be carried out every month.

1. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
2. Check for material buildup on the probe. If required, probe cleaning to be done using cleaning agent which is resistant to the probe insulation.
3. Process seals to be checked and replaced if needed.
4. Check the electrical cable connection is proper and the gland is tightened properly.
5. The reading of the capacitance switch is verified with the liquid in the tanks. If any issues are found in the signal then further investigations are carried out as mentioned in the functional check.

Functional Check:
This involves further troubleshooting of the instrument through the LED status of the electronics and the current through the terminals.

Troubleshooting:

1. The LED 1 and 3 of the electronic card on capacitance switch flashes if any maintenance is required on the switch.
2. The LED 1 flashes and led 3 is solid red if the card is faulty.



3. The current through terminal 1 and 3 i.e. Ir <100 micro amperes in case of any alarm (power failure or device failure).

Fault Diagnostics:

Fault diagnostics is to be performed if the probe is not functioning properly and issue is found during troubleshooting. Refer to Section 9.1.1 of the Operating Instructions (BA00299F/00/en/13.10) for details on the fault diagnostic method of the electronics.

CALIBRATION:

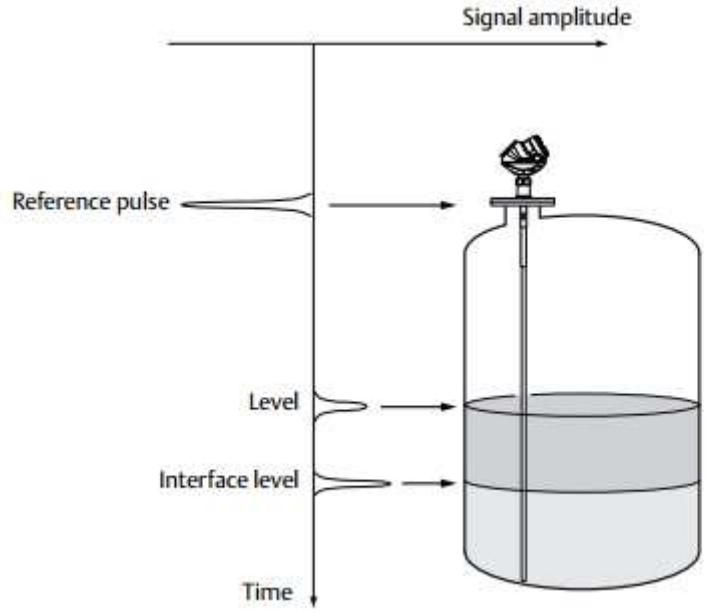
Nothing is mentioned for calibration requirements of the instrument in the Vendor documents. As per local requirement of the Flow Loop, it should be carried out **every 2 years** or in case of failure of the instrument.

Reference:

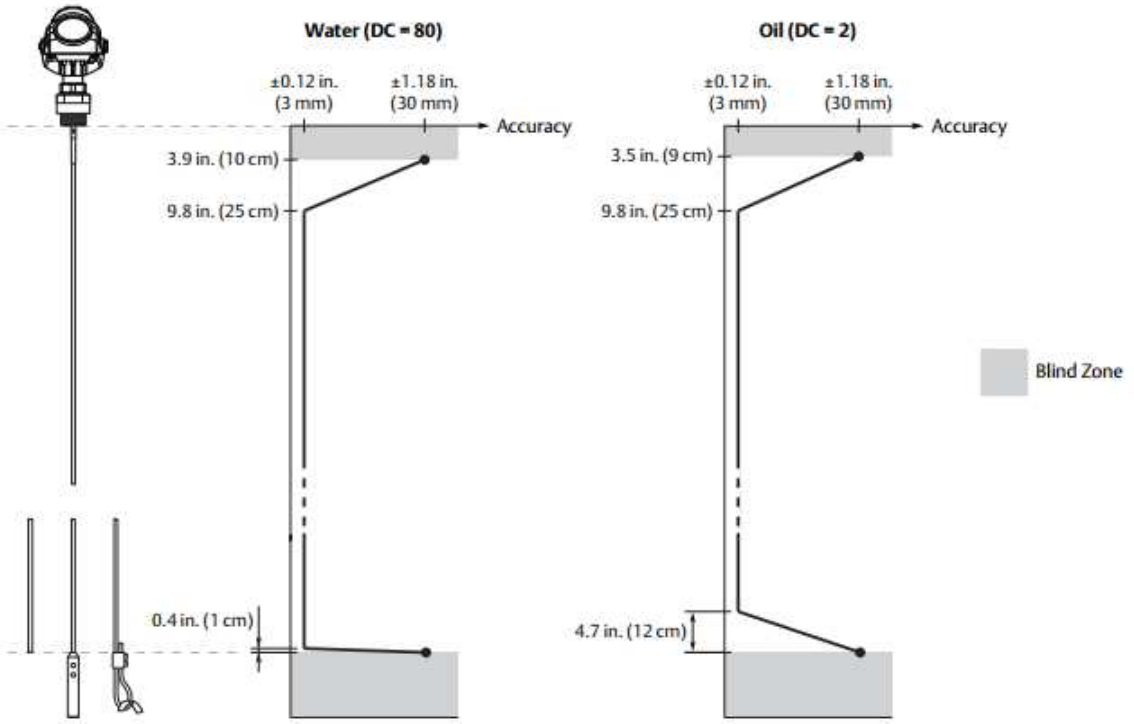
1. Technical Information - TI00417F/00/en
2. Operation Manual - BA00299F/00/en/13.10
3. PO Number: 10308941
4. Supplier Contact Person : JK Lim
   Email ID: loh.meefoo@sg.endress.com
   Phone Number: 66522721

A-9 GUIDED WAVE RADAR: Rosemount5300 Series

The Rosemount 5302 is a good choice for measuring the interface of oil and water, or other liquids with significant dielectric differences. The various peaks are formed at the position of reflections as shown below:



Accuracy of GWR varies based on the blind space in the tank, we are using Single Lead Probes in Flow Loop and accuracy is defined as below:

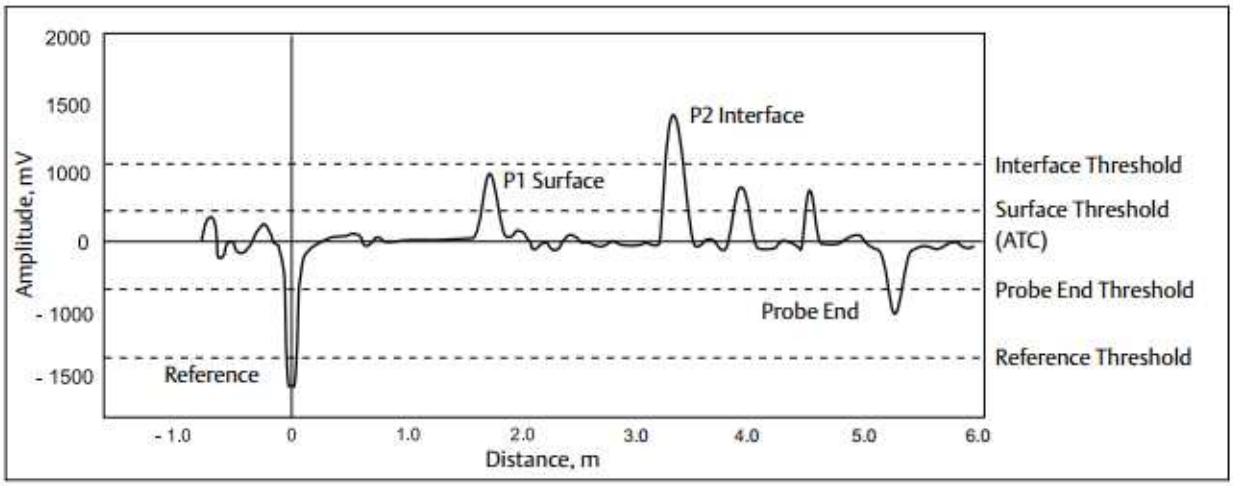


Preventive Maintenance:
This should be carried out every 3 month.

1. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
2. Heavy contamination or product build-up on the probe should be avoided since it may decrease the sensitivity of the transmitter and lead to measurement errors. In viscous or sticky applications, periodic cleaning may be required. Maximum measurement error due to contamination is 1-10% depending on probe type, dielectric constant, contamination thickness and contamination height above product surface.
3. Check the grounding wire is connected to the external terminal.
4. The surge arrestor is installed and connected to the terminals.
5. Check the electrical cable connection is proper and the gland is tightened properly.

Functional Check:
This involves further troubleshooting of the instrument through the transmitter Modbus or HART convertor. Radar Master Software is used for checking different parameters.
Troubleshooting:

3. Check the echo curve of the sensor for different peaks. The curve should match as commissioning echo curve. Reference curve is as shown below:



4. Remember to take As_Found and As_left backup from the Radar Master Software

Fault Diagnostics:
Fault diagnostics is to be performed if the probe is not functioning properly and issue is found during troubleshooting. Refer to Section 7 of the Reference Manual (00809-0100-4530, Rev DB) for details on the fault diagnostic method of the electronics.

Reference Documents

1. Product Data Sheet, 00813-0100-4530, Rev FA
2. Reference Manual (00809-0100-4530, Rev DB)

A-10 ULTRASONIC LEVEL SENSOR: Rosemount3101 Series

The Rosemount 3101 transmitters are designed to be mounted above a liquid and use ultrasonic pulses to continuously measure the distance to the liquid surface. The microprocessor-controlled electronics calculate the distance to the liquid level from the time delay between the transmitting and receiving of the signals. When programmed with the bottom reference of the application, usually the tank bottom, the transmitter calculates the liquid depth (level) and outputs the level as a 4–20 mA signal. The 3101 calculates the level only and then outputs the result as a 4–20 mA signal.

The accuracy of level sensor Rosemount 3101 is defined as below:
0.2 in. (5 mm) for < 3.3 ft. (1 m), ± 0.5% of measured distance for > 3.3 ft. (1 m)

Preventive Maintenance:
This should be carried out every 4 month.

1. The equipment must only be cleaned with a damp cloth; do not use solvents.
2. Check the transmitter face to ensure it remains clean and check that the cover seal, wiring, and cable glands are in good condition.
3. The transmitter is Double Insulated, and therefore Protective earth is not required. However, the cable shield/screen should be connected to a suitable ground (earth) at one end only.
4. Check the electrical cable connection is proper and the gland is tightened properly.

Configuration:
In case the transmitter is changed due to any problems, configure the limits of the transmitter as mentioned in Section 4.3 of the Reference Manual.

Fault Diagnostics:
Fault diagnostics is to be performed if the probe is not functioning properly and issue is found during troubleshooting. Refer to Section 5.3 of the Reference Manual (00809-0100-4840, Rev CB) for details on the fault diagnostic method of the electronics.

Reference:

1. Reference Manual (00809-0100-4840, Rev CB)
2. PO Number: 10306576
3. Supplier Contact Person : Michelle Lee
   Email ID: michelle.lee@emerson.com
   Phone Number: 6770 8109

A-11 COMPRESSOR AND BSOS (C101A)

Preventive Maintenance

1. Check the bearing oil level (weekly). Refill / change if necessary
2. Sealing system: check the filters and replace if contamination indicator is active (weekly)
3. Sealing system: check the seal oil level and top up if necessary (weekly)
4. Sealing system: check the temperature of the seal oil (weekly)
5. Sealing system: replace the seal oil every 3000 operating hours
6. Sealing system: visual inspection for leak-tightness (weekly)
7. Sealing system: clean the air cooling components (monthly)
8. Sealing system: Replace the air filter (every 120 days)
9. Sealing system: Replace the hose lines (every 2100 days)
10. Check the alignment of motor with pump (1 Year)

Compressor and BSOS Maintenance from Supplier:

1. Compressor Oil change – After every 500 hrs. The Oil level should be just above red dot. Can be changed after 500 hrs for first maintenance. Later, Refer the documents to check for later maintenance. Can be done after few months or if it looks too dirty (color changes to dark brown). Atleast, 3 months after the first 200 hrs. Later, 3000 operating hrs or after 6 mnths atleast. Then, replace air filters over the gear every year.
2. Alignment check once a year is also recommended.
3. BSOS System: Hydraulics Unit (Seal) oil change – After every 2000 hrs
4. The oil level to be maintained below max. level. The nitrogen press. to be released before changing the tank oil. The Control panel should be switched off to remove energization of the Valves.
5. Filter check – regularly by checking the red pin position (Red pin out means need to change)
6. Nitrogen pressure check – Every 2 -3 weeks. It should be 30 bar in the nitrogen cylinder. The pressure in the tank should be released by opening the safety valve before checking the pressure in the cylinder.
7. Air filter granules replacement or regeneration once it turns green.

The 2 valves flowing to the mechanical seals should always be in-line supplying the compressor else the hydraulics system will be in bypass.

VFD Check

1. Visually inspect the VFD for any physical damage (Quarterly).
2. Check for any alarm on the VFD (Monthly).
3. Contact the VFD supplier for further investigation (If required).

Reference:
Pump: Stephen Sim (stephen.sim@bornemannasia.com),65616782,
PO Number: SIP 00078
VFD: Ricky Chua (Ricky.chua@sg.abb.com), 67735859,
PO Number: SIP 00134

A-12 CENTRIFUGAL PUMPS (P103 and P105)

Preventive Maintenance:

1. Check for any leaks from gaskets and seals. (weekly)
2. Check that shaft seal leaks are within acceptable limits. Must not exceed more than 5 drops per minute in normal operation (weekly)
3. Check bearing lubricant level (weekly)
4. Replace the lubricant (6 monthly)
5. Check vibration, noise level and surface temperature at the bearings to confirm satisfactory operation (weekly)
6. Check coupling alignment and re-align if necessary (6 monthly)
7. Check foundation bolts for security of attachment (6 monthly)
8. Check internal pump components for wear (3 yearly)
9. Change bearings (3 yearly)

Functional Check:
In case of any issues found during normal operations or during preventive maintenance, further checks are carried out on motor and VFD.

Motor Check

1. Check the motor is not getting heated up while in operation.
2. Check the current drawn by motor is same as nominal current rating of the motor at no load.

If not Ok, proceed for individual check of the motor. This would require dismantling the coupling and checking the motor separately.

NOTE: Remove the electrical connections before proceeding for checking the motor

The checks on the motor are as follow:

1. Check the shaft can be rotated with hand in clockwise and anticlockwise direction.
2. Check the resistance on the terminals is same for all the 3 phases after disconnecting the motor cables.
3. If the test fails, it means motor winding has a problem.
4. Contact the motor supplier for repair.

VFD Check

1. Visually inspect the VFD for any physical damage (Quarterly).
2. Check for any alarm on the VFD (Monthly).
3. Contact the VFD supplier for further investigation (If required, in case of service).

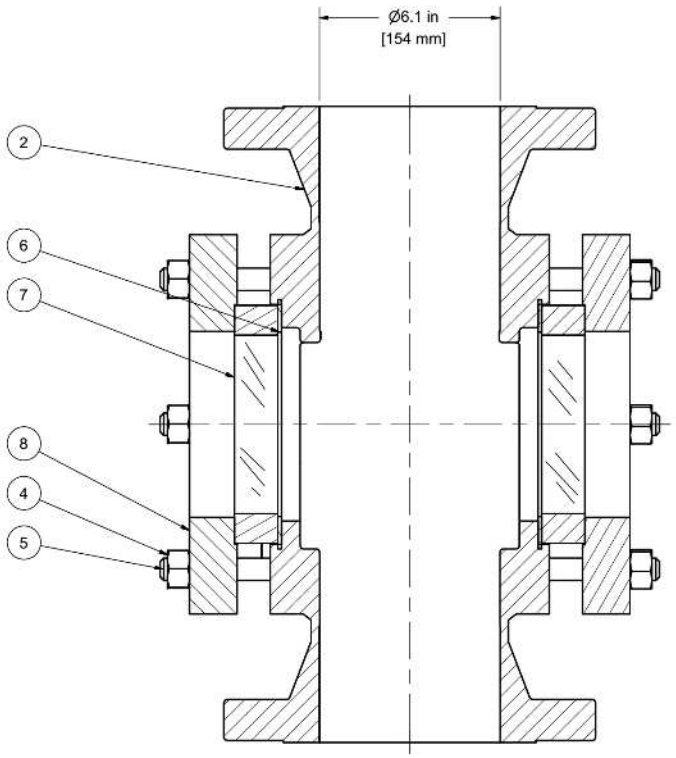
Reference:

1. Pump: Sachin Patil (914222612075)
    i. PO Number: SIP 00111
2. VFD: Ricky Chua (Ricky.chua@sg.abb.com), 67735859,
    i. PO Number: SIP 00134

A-13 SIGHT FLOWS (FG 1402, FG1401 and FG 1602)

Procedure for replacing the gaskets

1. Loosen / remove the retaining flange nuts / studs (items 4 & 5 on drawing), and retaining flange (item 8 on drawing)
2. Remove sight glass (item 7 on drawing) and clean wetted / gasket sealing face
3. Remove existing gasket (item 6 on drawing) and clean gasket face of flow cell body (item 2 on drawing)
4. Position new gasket in place and sit sight glass on top of it.
5. Positon retaining flange in place and uniformly retighten nuts / studs in a crisscross pattern using a torque of 60-80 ft.lbs (suitable for buna gaskets)



SECTION A-A

Reference:

1. PO Number: SIP 00179
2. Supplier Contact Person : Mr. LK Ong
   Email ID: ls_ong@ronsor.com.sg
   Phone Number: 67792818

A-14 **VACUUM PUMP (P113)**

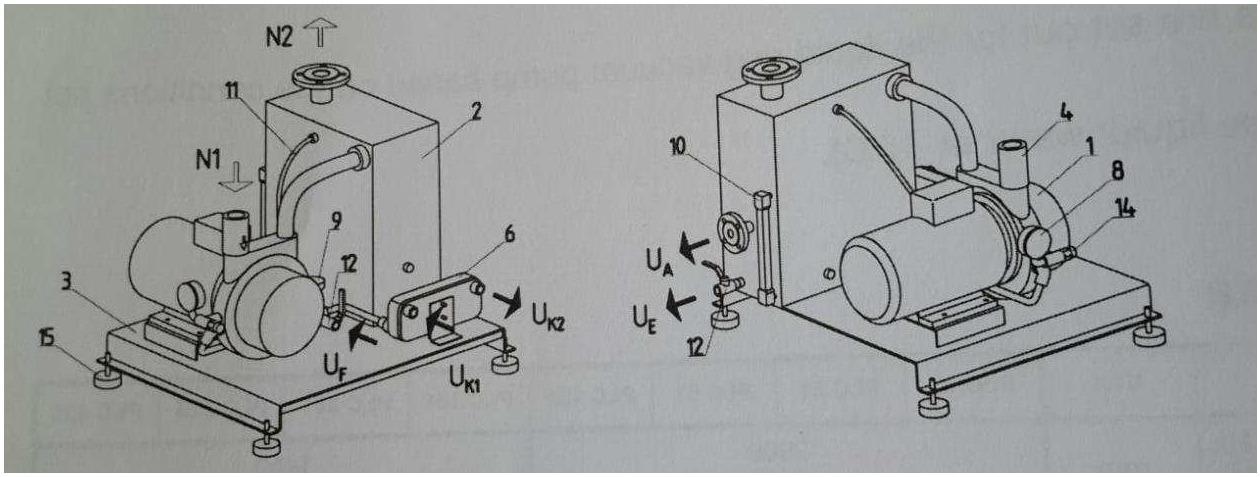


Fig 1 : Single stage liquid ring vacuum pump

Preventive Maintenance:

1. Check for any leaks from gaskets and seals. (weekly)
2. Regular desilting or system fluid exchange is necessary. This could be done by keeping Ua overflow or the Ue drain connection must flow out freely without pressure and then refill with fresh water upto the center of the separator (U_f) (3 Months)
3. Upstream filters in the fresh fluid and cooling water feed must be checked (Annual)
4. Check the fittings for any visible damage (6 months)

Functional Check:

In case of any issues found during normal operations or during preventive maintenance, further checks are carried out on motor.

Motor Check

3. Check the motor is not getting heated up while in operation.
4. Check the current drawn by motor is same as nominal current rating of the motor at no load.

If not Ok, proceed for individual check of the motor. This would require dismantling the coupling and checking the motor separately.

NOTE: Remove the electrical connections before proceeding for checking the motor.

The checks on the motor are as follow:

5. Check the shaft can be rotated with hand in clockwise and anticlockwise direction.
6. Check the resistance on the terminals is same for all the 3 phases after disconnecting the motor cables.
7. If the test fails, it means motor winding has a problem.
8. Contact the motor supplier for repair.

For troubleshooting, refer to SIHI LIQUID RING VACUUM PUMP TROUBLE SHOOTING GUIDE.

Reference:

1. BA 27891_EN_00 (Translation of the Original Instructions)
2. Sihi Liquid Ring Vacuum Pump troubleshooting guide.

3. PO Number: SIP 00128
4. Supplier Contact Person : Mr. Freddy Foong
   Email ID: freddy.foong@sihipumpasia.com
   Phone Number: 65628306

A-15 **CHILLERS**

Chiller System comprising of 2 Compressor units and a buffer tank is used for cooling the Flow Loop.

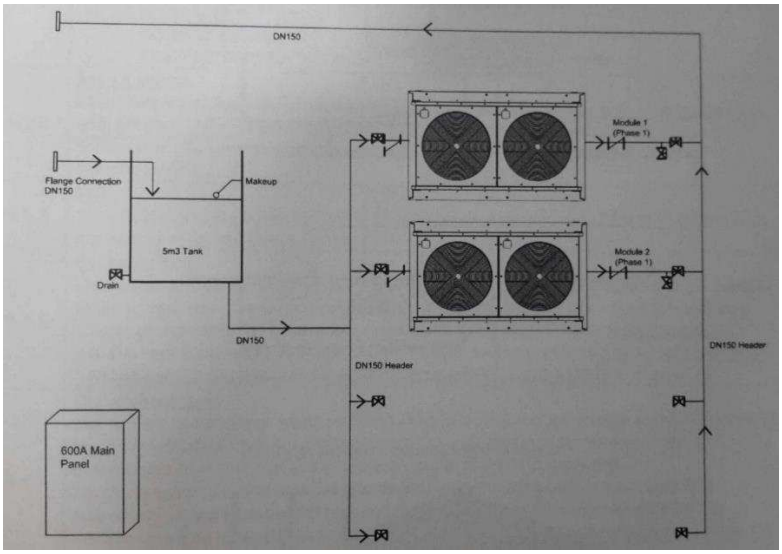


Fig 1: Chillers Distribution System

The maintenance of Chillers is explained in detail in Periodic Maintenance List for Shelton Chillers. The main maintenance steps are as below:

1. To clean and inspect condenser (2 Months).
2. Check Quality of Water (Monthly)
3. Test Glycol Mixture (2 Months).
4. Pressure of fluid (Monthly)
5. Inspect Strainer (3 Months)
6. Replacement of inlet water filter (3 Months, if applicable)
7. Inspect fluid system i.e. leak from any part of the system (Annual)
8. Test voltage and ampere draws (Annual)
9. Inspect mechanical components (Annual)
10. Check control panel wiring (6 Months)
11. Inspect and test refrigerant system (Annual)
12. Keep panel's electrical components clean (6 Months)

Reference:

1. PO Number: 10310993
2. Supplier Contact Person : kye Tan Kaiwei
   Email ID: sale@shelton.com.sg
   Phone Number: 67455553

A-16 **CORIOLIS METER**

Coriolis flowmeters precisely measure mass flow. Separately and independently from the mass flow measurement, Coriolis meters also measure liquid density. Coriolis mass flowmeters use these two measurements to calculate volumetric flow. Because of their inherent accuracy of 0.1 % (depending on the size of the meter and the flow rate), minimal maintenance, and absence of moving parts to wear out, they are used in Flow Loop as a primary meters for all the 3 fluids.
The meter we have in Flow Loop is a basic meter with no features of Smart Meter Verification.
Preventive Maintenance:
This should be carried out every month.

- **Visual Check:**

5. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
6. Check the Modbus connection from transmitter to control system is working fine.
7. Check for any alarm on the LOI (Local Operator Interface).
8. Check the zero flow reading of the meter after removing the cutoff from the meter.

- **DAUDA:**

The reading of the meter should be verified with the Coriolis meters in the line (Every 2 months) in the overlapping range. The accuracy of the meter is 0.1 % of the flow rate.

- **Zero and Calibration Check:**

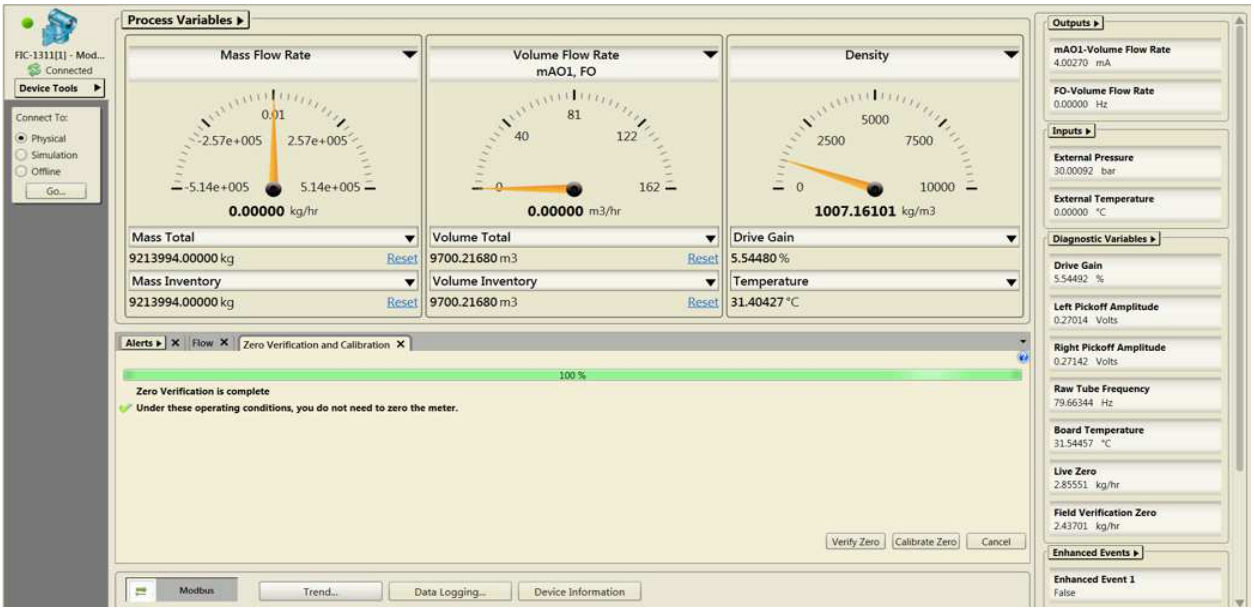


Image 1 : Screenshot from Prolink software after zero verification is passed

This involves further troubleshooting of the instrument if we suspect any error in the DAUDA stage. Check the zero of the instrument by keeping the lines full of liquid and closing the valves on both the sides of the meter. Check for reading of the meter at zero flow. If any error is found at zero flow, proceed to perform zero trim for the meter. Run the zero verification on the meter to verify zero stability. The meter should pass zero verification.

NOTE: Remove the min. flow cut off set in the meters before checking the zero deviation. Also remember to save the AS_FOUND settings and configuration parameters.
Zero verification of the meter can be performed using Prolink software. If the error still exists then further checks are required on the sensor.

Functional Check:
Check the Drive parameters of the Coriolis meter and compare it with the previous values. Furthermore, the tube frequency should not fluctuate for the stable flow across the meter. An unstable frequency might indicate some tube wearing.

In prolink, click on Diagnostic Information for further analysis:

- Right pickoff and left pickoff shall be about equal to tube frequency (Hz) x 0.0026 V. If not, Coriolis flow tube might be dirty or eroded
- If the drift in flow measurement is still present, Coriolis meter functional check is carried out by supplier using Smart Meter Verification techniques and recalibrating the meter.

Fault Diagnostics:
The fault diagnosis is performed by supplier for any major issue in the Coriolis meters

Reference:

3. Testing Services\1648419325\SPFM A and SPFM B\Maintenance and Troubleshooting
4. PO Number: SIP00125
5. Supplier Contact Person : Kendrick Tan
   Email ID: Kendrick.tan@emerson.com
   Phone Number: 6770 8109

A-17 **FLOW SWITCH:E+H:DTT31**

The device measures the mass flow of a liquid medium with the calorimetric measurement method. The calorimetric measuring principle is based on cooling a heated temperature sensor. Heat is removed from the sensor by forced convection due to medium flowing by. The extent of this heat transfer depends on the medium velocity and the difference in temperature between the sensor and medium (King's law). The higher the velocity or the mass flow of the medium, the greater the temperature sensor cooling. Maximum measured error = switch point error and display error + 0.1%

Preventive Maintenance:
This should be carried out every month.

- **Visual Check:**

1. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
2. Check for any alarm on the LOI (Local Operator Interface). Refer to the diagnostics messages mentioned in the Operating Instructions Manual:Section8 (BA00235R/09/EN/16.14) for the list of Error Messages and their corrective action.
3. Check the electrical cable connection is proper and the gland is tightened properly.

- **DAUDA:**

The reading of the meter should be verified with the Coriolis meters in the line (Every 2 months) in the overlapping range.

- **Zero and Calibration Check:**

This involves further troubleshooting of the instrument if we suspect any error in the DAUDA stage. Check the zero of the instrument by keeping the lines full of liquid and closing the valves on both the sides of the meter. Check for reading of the meter at zero flow. If any error is found at zero flow, proceed to perform zero trim for the meter. Refer the Operating Instructions Manual (BA00235R/09/EN/16.14) for the procedure. The meter can also be calibrated for HI Flow as per the procedure mentioned in the Operating Instructions. If the error still exists then further checks are required on the sensor.

Functional Check:

This is required if the reading from the flow meter is still not in the accuracy range even after zero and calibration check. It involves checking for buildup on the sensor. Any buildup on the sensor can have a negative effect on the accuracy. For this reason, check the sensor for buildup at regular intervals.

NOTE: Make sure the process is unpressurized before you remove the device! Do not twist the device out of the process connection thread at the housing. Always use a suitable open-ended wrench for disassembly work. For disconnection, refer the section 3.3.1 of the operating instructions.

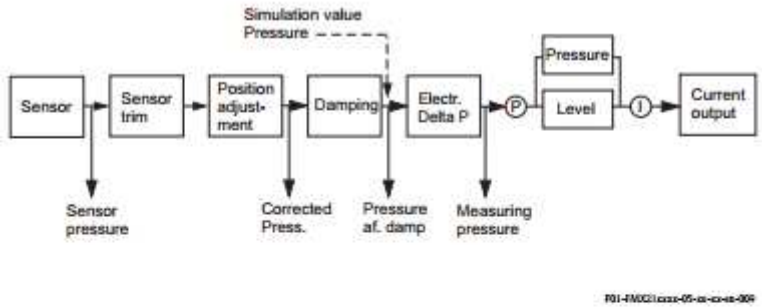
Fault Diagnostics:
Fault troubleshooting is explained in detail in Section 8 of the Operating Instructions (BA00235R/09/EN/16.14).

Reference Documents

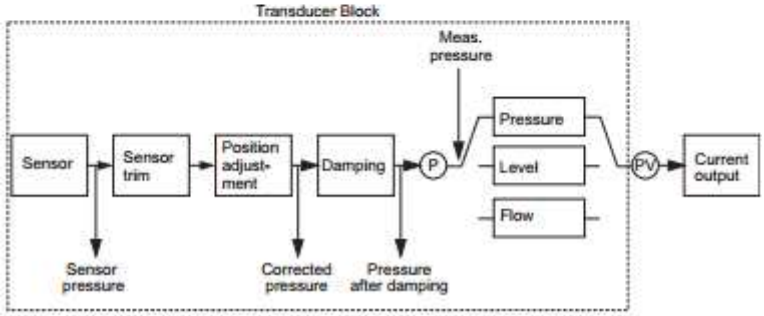
1. Operating Instructions (BA00235R/09/EN/16.14)
2. Technical information Flow switch Flowphant T DTT31, DTT35 (TI00125R/09/EN/02.14)

A-18 **PRESSURE TRANSMITTER: PMC51&PMC71**

The pressure transmitters are used in all the three (Oil, Gas and water) phase lines of the flow loop. The measurements from some of the pressure transmitters are used in the flowmeter calculations and hence they are important instruments from the metrology point of view.
The transmitter data flow is as shown below:



Deltabar M:



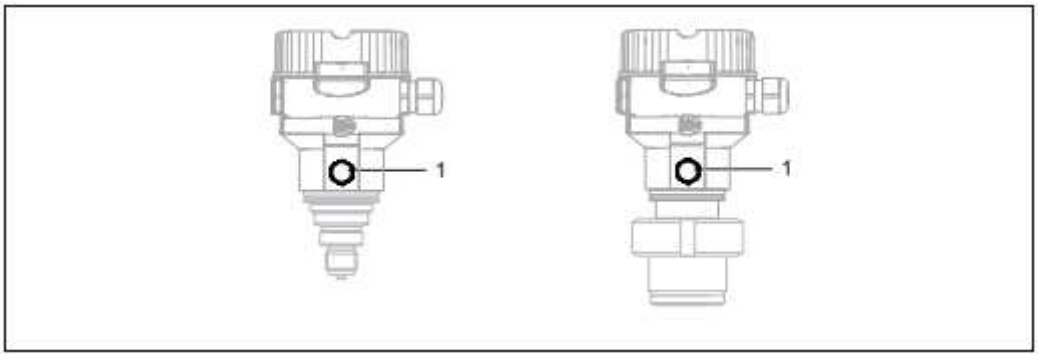
If any discrepancy in the reading of the transmitter is found and needs to be corrected, we should sequentially check the reading of meter from right to left i.e. starting with D/A towards A/D and lastly the sensor. It is a way to isolate the problem in the different sections of the instrument.

Preventive Maintenance:

This should be carried out **every month**.

- **Visual Check:**

9. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).



10. Keep the pressure compensation and Gore-tax filter (1) free from contamination.
11. Check the electrical cable connection is proper and the gland is tightened properly.

12. Check for any alarm on the LCD screen.

- **DAUDA:**

The reading of the meter should be verified with the other transmitters in the line (Every 2 months). Remember to check the pressure at the same ambient conditions. The accuracy of PMC51 is 0.15 %.

- **Zero and Calibration Check:**

Check the zero of the instrument by keeping the pipeline at atmospheric pressure and reading the value on the display. This involves further troubleshooting of the instrument if we suspect any error in the DAUDA stage. Follow the zero process as mentioned in Section 6.4 of the Operation Instruction manual.
NOTE: Record As_Found configuration values of the instrument before proceeding with any kind of modification/calibration of the meter.
Functional Check:
If some error is found during normal operation cycle, the troubleshooting involves the procedure mentioned in preventive maintenance section and further checks can be done for fault diagnostics.
Fault Diagnostics:
Fault troubleshooting is explained in detail in Section 8 of the Operating Instructions Manual (BA382P/00/EN/10.09).

Reference:

1. Operating Instructions Manual (BA382P/00/EN/10.09)
2. PO Number: 10308941
3. Supplier Contact Person : JK Lim
   Email ID: loh.meefoo@sg.endress.com
   Phone Number: 66522721

A-19 TEMPERATURE TRANSMITTER : E+H: TR13&TR10,WIKA

The temperature transmitters are used in all the three (Oil, Gas and water) phase lines of the flow loop. The temperature measurement is critical from the safety and process point of view. On the gas line, we need to maintain temperature below 60 ^{o}C and we should maintain constant temperature on the liquid lines to keep the viscosity same.
The transmitter accuracy is as defined below:

Transmitter specifications

	iTEMP® TMT180 PCP Pt100	iTEMP® TMT181 PCP	iTEMP® TMT182 HART®	iTEMP® TMT82[1] HART®	iTEMP® TMT84 PA iTEMP® TMT85 FF
Measurement accuracy	0.2 °C (0.36 °F), optional 0.1 °C (0.18 °F) oder 0.08 %	0.2 °C (0.36 °F) or 0.08 %		0.1 °C (0.18 °F)	
	% is related to the adjusted measurement range (the larger value applies)				
Sensor current	I ≤ 0.6 mA		I ≤ 0.2 mA	I ≤ 0.3 mA	
Galvanic isolation (input/output)	-	U = 2 kV AC			

1) Entire accuracy = 0.1 °C (0.18 °F) + 0.03% (D/A-accuracy)

Transmitter long-term stability	≤ 0.1 °C/year (≤ 0.18 °F / year) or ≤ 0.05% / year Data under reference conditions; % relates to the set span. The larger value applies.

The transmitter used in FL is TMT82 (accuracy of 0.1 ^{o}C)
If any discrepancy in the reading of the transmitter is found and needs to be corrected, we should sequentially check the reading of meter from right to left i.e. starting with D/A towards A/D and lastly the sensor. It is a way to isolate the problem in the different sections of the instrument.

Preventive Maintenance:
This should be carried out **every month**.

- **Visual Check:**

13. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
14. Check the value on the local display of the transmitter (Different characters on the extreme right of the display eg: F,C,S and M have different meaning).Refer the Brief Operating Instructions iTEMP TMT82 manual for further details.
15. Check the electrical cable connection is proper and the gland is tightened properly.
16. Check for any alarm on the LCD screen.

- **DAUDA:**

The reading of the meter should be verified with the other transmitters in the line (Every 2 months). Remember to check the temperature at the same ambient conditions.

- **Calibration Check:**

Calibration of the temperature transmitters in carried out by third party in case any noticeable drift is seen in the readings during the DAUDA stage.

Functional Check:
If some error is found during normal operation cycle, the troubleshooting involves the procedure mentioned in preventive maintenance section and further checks can be done for fault diagnostics.

Fault Diagnostics:
Fault troubleshooting is explained in detail in Section 8 of the Operating Instructions Manual (BA382P/00/EN/10.09).

For Wika bimetal thermometers, no special maintenance is required. Just keep them clean.(Monthly)
Calibration should be checked periodically to check the accuracy (2 Yrs)

Reference:

1. Brief Operating Instructions iTEMP TMT82 Manual (KA01095T/09/EN/16.14)
2. Technical Information Omnigrad M TR10 (TI00256T/09/en)
3. Wika Operating Instructions Models 53,54,55
4. PO Number: 10308941
5. Supplier Contact Person : JK Lim
   Email ID: loh.meefoo@sg.endress.com
   Phone Number: 66522721

A-20 **LEVEL SWITCH: E+H: FTL51**

The switch has no moving parts so it does not require any major maintenance. Few checks which should be performed are as below: Maximum measured error under reference operating conditions is: max. +/–1 mm (0.04 in)

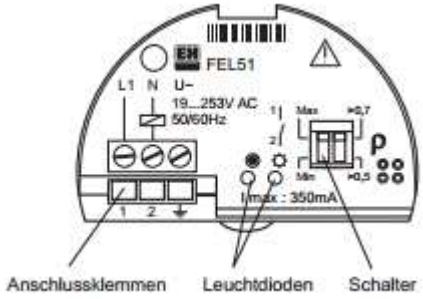
Preventive Maintenance:

This should be carried out every month.

17. Exterior cleaning is to be done using cleaning agents that should not affect the surface of the housing or the seals. Anti-rust solvents is to be used on the housing (if required).
18. Process seals to be checked and replaced if needed.
19. Check the electrical cable connection is proper and the gland is tightened properly.

Functional Check:

This involves further troubleshooting of the instrument through the LED status of the electronics.



Troubleshooting:

- 2 switches for safety mode and density change
- Green LED to indicate operational status
- Red LED to indicate the switching status, flashes in the event of corrosion damage on sensor or if the electronics are defective.

Light signals

LED	Symbol	Information
Yellow		Measurement valid
		Unstable process situation
		Maintenance required
Green		Power on
		Power off
Red		No fault
		Maintenance required
		Device failure

Fault Diagnostics:

Fault diagnostics is to be performed if the switch is not functioning properly and issue is found during troubleshooting. Output signal on power failure or in the event of damaged sensor: < 100 µA.

CALIBRATION:

Nothing is mentioned for calibration requirements of the instrument in the Vendor documents. As per local requirement of the Flow Loop, it should be carried out every 2 years or in case of failure of the instrument.

Reference:

1. Technical Information – TI328F/00/en/15.15
2. PO Number: 10308941
3. Supplier Contact Person : JK Lim

Email ID: loh.meefoo@sg.endress.com
Phone Number: 66522721

A-21 **MANUAL VALVES IN TESTING SECTION**

The manual globe valves in testing section are to be checked for any possible leak through the valves as it will affect the measured flow through the meters connected on the test stations and in a way affect the accuracy of the Flow Loop.

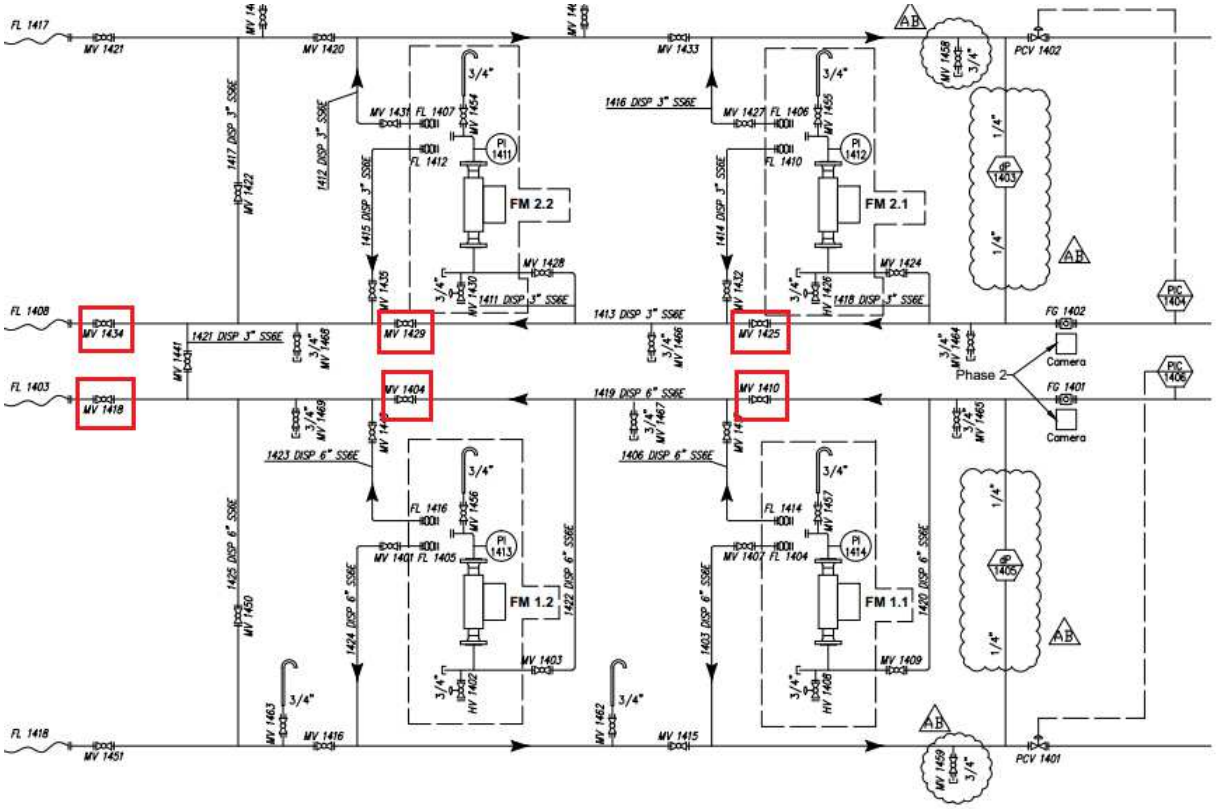


Fig 1 : Testing Section Inlet Manual Valves

Preventive Maintenance:
This should be carried out **annually**.

The procedure is defined for 6" line, it should be followed the same way for 3" line (just replace MV1410, MV1404, MV1418, MV1467 and MV1469 with MV1425, MV1429, MV1434, MV1466 and MV1468 respectively).

MV1410

1. Open all the valves on the 6" line up to the MV 1410(closed).
2. Flush the line with gas until the line is dry (check from sight glass FG1401).
3. Isolate the section by closing the bypass valve MV1450 on the downstream side and closing MV1410 on the upstream side.
4. Vent the gas from isolated section from MV1467.
5. Start the water pump with Vx meter connected on Test Station FM1.1 (to define return path for water).
6. Start with checking the valve MV1410 first, keeping upstream pressurized at 28 Bar.
7. Check for any water drops from the drain MV1467. No water dripping out means no leakage.

MV1404

1. Close valve MV 1404
2. Connect water hose to the drain valve MV1467 and fill the section from MV1404 to MV1410with water.
3. Close the drain MV1467
4. Open the valve MV1410 to pressurize the section up to valve MV 1404 (28 Bar).
5. Open the drain valve 1469 to check for any water dripping out. If not, the valve MV1404 is not leaking.

MV1418

1. Keep the valve MV1404 closed
2. Connect hose to MV1469 and fill the section with water.
3. Open the valve MV1404 to pressurize the line up to MV 1418.
4. Open the bleed valve at blind flange to check for any water drops on the bleed valve. If not, valve MV1418 is not leaking.

A-22 **LIMIT SWITCHES**

Functional Maintenance:

Limit switch is used in the Valves for the feedback status to the control system and local position. Error in limit switch will normally be seen by wrong status of the valve. Will need to replace the switch for actuator valves and set the position for the magnet in case of wrong feedback to the control system.

A-23 TRANSFER PUMP (P109)

Preventive Maintenance:

1. Check for rust on any part of the pump and clean with antirust (Monthly)
2. Check level of bearings grease and refill if required (Monthly). The grease used for bearings should be British Petroleum's "BP LC2" or Mobil Grease "XHP-222".
3. Inspect pumping elements for wear and tear (6 Month)
4. Monitor the temperature rise of the pump while running.
5. Simulate the temperature switch alarm (TISH 1617) to check shut down of pump at high temperature (6 Months).

Functional Check:
In case of any issues found during normal operations or during preventive maintenance, further checks are carried out on motor.
Motor Check

5. Check the motor is not getting heated up while in operation.
6. Check the current drawn by motor is same as nominal current rating of the motor at no load.

If not Ok, proceed for individual check of the motor. This would require dismantling the coupling and checking the motor separately.
NOTE: Remove the electrical connections before proceeding for checking the motor.
The checks on the motor are as follow:

9. Check the shaft can be rotated with hand in clockwise and anticlockwise direction.
10. Check the resistance on the terminals is same for all the 3 phases after disconnecting the motor cables.
11. If the test fails, it means motor winding has a problem.
12. Contact the motor supplier for repair.

Reference:

1. Operation and Maintenance Manual --- Roto Pumps Ltd
2. PO Number: SIP00133
3. Supplier Contact Person : N.Sethunath
   Email ID: sales@liquimech.com
   Phone Number: 68969113

A-24 **SAFETY VALVES (LESER)**

Preventive Maintenance:

1. Check for rust on any part of the valve and clean with antirust (2 Yrs)
2. Check screw connections(2 Yrs)
3. Check attachments for any visible damage (2 Yrs)
4. Check for any leak (2 Yrs)

Reference:

1. LESER Operating Instructions --- LESER
2. PO Number: SIP00204
3. Supplier Contact Person :Daniel Ang
   Email ID: ang.d@leser.com.sg
   Phone Number: 96530265