NLS PROCEDURE

Dismantle, Inspection and Failure Analysis (DIFA)

NLS-QHSE-P72

Revision: **3**

Date: **08 June 2022**

Scope: All NOVOMET Locations - Global

Author:	**Reviewer:**	**Approver:**
Quality Assurance Engineer Head of KPI control group	International Technical Manager IMS Administrator International	International QA/QC Manager

01. Purpose

Dismantle, Inspection and Failure Analysis (DIFA) Procedure determines:

- General stages and requirements of investigation of ESP Failures and non-standard cases of failure
- Responsibilities
- Documents that shall be issued during DIFA

The main goals of the DIFA are:

- To determine the failure Root-Cause.
- To take anticipatory actions on the ESP Failure
- To make correction (if applicable)
- To improve quality process based on the information received during DIFA

02. Scope

DIFA procedure is applicable in all NLS B.V. locations. The procedure is applicable in the following cases of equipment failure:

- Failure during warranty period.
- Special contract requirements.
- Customer's request.
- Supervised operation of equipment.
- Non-conventional cases of failure (falling of downhole equipment to bottom-hole, etc.).

03. HSE Requirements

3.1. Requirements for newly hired employees

All newly hired employees are subject to HSE orientation as per NLS-QHSE-P62 and NLS-QHSE-P39 (without reference to a job):

- Preliminary medical examination;
- HSE introduction;
- HSE introduction regarding the certain job in the first working day;
- During the first working month employees are subject to HSE training (safe working methods and the first aid).

3.2. Required certificates:

All employees involved in DIFA Process shall be trained as per NLS-QHSE-P11.
All employees involved in DIFA Process shall have the following certificates:

- HSE certificate with a note about the first aid training.
- Electrical safety certificate (corresponding risk group) for employees, working with electrical installations and/or test benches.
- Hoisting certificate for employees, working with hoisting equipment (overhead cranes, bridge cranes, cranes-manipulators, truck cranes, etc.).
- Employees, working with machine treatment equipment (turning lathe, milling machine, grinding machine etc.), shall have the corresponding training certificate or a record about the corresponding experience
- Driving license for the corresponding type of vehicle for Employees, driving a car.
- Forklift operator certificate and driving license for forklift operators.

3.3. Requirements to PPE:

Personal protective equipment is visually checked by an employee before usage.
Protective clothing: cotton overall, leather boots with hard toes, gloves or gauntlets.
Additional PPE:

- Headphones or earplugs – in case of noise high level
- Protective glasses – during working with machines
- Helmet – during working with hoisting equipment
- Dielectric gloves, insulating mat – during working with electric installations
- Helmet, safety belt – during working at height
- Safety belt – during working on ladders (higher than 1.3 meters)
- Respirator, protective glasses, acid base resistant gloves – during working with chemicals (solvents, paint, metal dust, etc.)

Additional PPE in winter: warm clothes, warm boots, warm gauntlets, inner helmet.

3.4. General HSE Requirements during DIFA Process:

- In case of working under extreme temperatures, follow NLS-QHSE-P45.
- In case ofH2S, follow NLS-QHSE-P41.
- In case of NORM, follow NLS-QHSE-P20.
- A Job Safety Analysis/Task Risk Assessment shall be performed as per NLS-QHSE-P68 before commencement of the DIFA process and the risk and hazards shall be communicated with the workforce involved in DIFA during Pre-Job Briefing as per NLS-QHSE-P56.

- Any unsafe conditions or HSE concerns shall be raised by employee using safety observation cards as per NLS-QHSE-P8.
- All the incidents shall be promptly reported by the employees to their immediate supervisor as per NLS-QHSE-P09.
- Employee shall raise a STOP WORK AUTHORITY in case of any issues which may pose serious impact on the health and safety for the employees and shall not continue the job until the issues/concerns are rectified as per NLS-QHSE-P36.

3.5. Additional requirements during dismantling:

- Electrical safety and hoisting certificates should be on rig's operators.
- It is strictly forbidden to joint shaft and spline coupling between flanges manually.
- Ensure ring pump/motor clamp nose fits obligatory into groove on head and pump/motor clamp lock is tightened by nuts during pump/motor clamp installing on unit (but don't overtighten).
- Ensure tools and small parts are not fallen into well during installation and dismantling operations. It could lead to complications when running/pulling out the unit use some cover to prevent falling.
- During mounting rig's operator wear should be proper, without cuts and upright scraps.
- Hoisting equipment is carried out within ¼ from unit ends, at the same time ensure angle between straps is not more than 90°.

3.6. Requirements to equipment

3.6.1 Requirements to the tools:

- Inspect manual bench-tool visually (screwdrivers, hammers, chisels, pliers, etc.). Tools cannot be used in case of cracks and splits.
- During inspection, the workplace shall be arranged in accordance with Workplace Arrangement procedure- NLS-OPS-WS-P4. Proper housekeeping shall be ensured during and after the inspection process.

3.6.2. Requirements to machine equipment:

- All rotating components of machines shall have guard panels, protective shroud and protective screen. A machine shall be equipped with wooden steps or a rubber mat. Special brushes are used for cuttings removal. Each machine has a list of employees, accepted to work on it.

3.6.3. Requirements to hoisting equipment:

- The hoisting equipment shall have the valid certification. The hoisting equipment shall be a marked with verification, load-carrying capacity, date of next inspection.
- Check a hook (for cracks), protective lock on a hook, hoisting sling (a tag, cuts, cracks). Check a control panel (buttons jamming). Check brakes of an overhead crane or a crane.

3.6.4. Requirements to measuring equipment:

- All the measuring equipment shall be calibrated and/or verified. Follow the procedure NLS-QHSE-P12.

3.7. Requirement to working on ladders:

Check availability of a tag (with a date of the next test) before usage. Wooden and metal ladders shall be checked for cracks and metal damage respectively.

3.7.1 Accommodation ladders: underside ends of a ladder shall be covered with rubber to prevent sliding. Top ends of a ladder shall be covered with special hooks, preventing ladder downfall.

3.7.2 Trestle ladders shall be equipped with hooks or chains to prevent movement.

It is prohibited to work on a ladder if test date is expired.
It is prohibited to work from two top steps without railings or supports.
It is prohibited to work on ladders when using electric or air tools; To execute electro-gas welding; On staircase.

3.8. Requirements to work at height:

Operations at height are all the operations, executed at height of 1.3 meters.

A manager has to give a written permission for high risky work. An employee is subject to additional HSE introductory to be explained of safety rules. Operations at height are conducted from scaffoldings. They shall be equipped with railings and to be fixed to reliable parts of buildings. Crowds of people are not admitted. Tools are lifted in special boxes.

3.9. Requirements to chemicals usage:

These operations are performed in special premises, chambers and exhaust hoods, equipped with supply and- exhaust ventilation. Ventilation has to be started for 5-10 minutes before operation in order to ventilate a room. Protective glasses, respirator and acid-base resistant gloves shall be used when working with chemicals.

3.10. In case of emergency: Manufacturing injury

To inform a supervisor and call for medical aid or emergency service.

To inform a supervisor, to call for emergency, to evacuate people from hazardous area, to cut power and to start breakdown elimination. If it is too hazardous, please wait for emergency services.
HSE requirements and personal protective equipment are applied in accordance with local procedures and legislation. Please contact local HSE representative in order to find more detailed HSE requirements and PPE to be applied.

04. References

This procedure conforms to the following international standard and NLS requirements:

- ISO 9000:2015
- ISO 9001:2015
- ISO 15551-1:2015(E)
- API recommended practice API 11S1
- NLS-QHSE-P7 Quality Control Procedure
- NLS-QHSE-P4 NCR Procedure
- NLS-QHSE-P5 CAPA Procedure
- NLS-QHSE-P30 Communications Procedure
- NLS-OPS-FS-MN-01 ESP system installation and dismantling manual
- NLS-OPS-FS-P2 Preliminary Inspection Failure Analysis
- NLS-QHSE-P39 Short Service Employee Program
- NLS-QHSE-P62 New Employee & Visitor Safety Briefing
- NLS-OPS-WS-P04 Workplace Arrangement procedure
- NLS-QHSE-P09 Incident Reporting & Investigation
- NLS-QHSE-P11 Training, Awareness and Competency Procedure
- NLS-QHSE-P17 Personal Protective Equipment
- NLS-QHSE-P20 NORM
- NLS-QHSE-P36 Stop Work Authority
- NLS-QHSE-P41 H2S
- NLS-QHSE-P45 Extreme Temperature
- NLS-QHSE-P56 Toolbox Talk Meeting Procedure
- NLS-QHSE-P8 Safety Observation
- NLS-QHSE-P68 Safety Analysis/Task Risk Assessment
- NLS-QHSE-P78 Management of Customer Claims Procedure
- NLS-QHSE-P67 Supervised operation of Novomet equipment
- NLS-OPS-WS-P2 Procedure for Development of Design and Technological Documentation
- NLS-OPS-WS-PR124 Oil Dielectric Strength Test
- NLS-OPS-WS-PR17 Gas Separator and Gas Handler 319, 338, 362, 406, 535 series. Teardown procedure
- NLS-OPS-WS-PR71 Gas Separator - Handler 362, 406 series. Teardown procedure
- NLS-OPS-WS-PR24 Permanent Magnet Motor 319, 406, 460, 512 series Teardown procedure
- NLS-OPS-WS-PR26 Asynchronous motor 378, 406, 460, 512, 562, 744 series Teardown procedure
- NLS-OPS-WS-PR69 PMM motor of 460 series 500 RPM Teardown procedure
- NLS-OPS-WS-PR28 Protector of 272 - 677 series Teardown procedure
- NLS-OPS-WS-PR29 Pumps of 272, 319, 338, 362, 406, 449, 535 and 677 series Teardown procedure
- NLS-OPS-WS-PR100 Pump of 272 (A) series Teardown procedure
- NLS-OPS-WS-PR14 Multiphase Pumps of 272, 319, 362, 406, and 535 series Teardown procedure

05. Definitions and Abbreviations

Anticipatory actions: The actions aimed at the detection of the previously known mistakes and solving the problem before the failure. Anticipatory actions reduce the negative impact on the service and costs related to the manufacturing, repair, and operation of the equipment.
CAPA Plan: Plan of Corrective and Preventive Actions
DIFA Report: The document completing during inspection, includes data of dismantling, inspection and determination of the Root-Cause of failure.
Disassembly: The process of taking the unit of equipment to pieces.
Dismantling: The process of equipment disconnection during POOH from the well.
ESP Units (components): Separate units of ESP System. ESP sections are as follows: Drain Valve, Check Valve, Pump Sections, Protectors, Motors, Downhole Sensors.
Early failure: ESP failure occurred during the period of operation from 3 days to 90 days inclusive.
Failure: The termination of the ability of an item to perform a required function. (ISO 15551-1)
Failed Item: Item that can no longer perform it’s required function. (ISO 15551-1)
Failure Descriptor: Apparent, observed cause of failure (of a Failed Item). (ISO 15551-1)
Failure cause: Circumstances during design, manufacture, or use which led to a failure. (ISO 15551-1)
Inspection: Commission investigation. The process of investigation of the general characteristics of the failed equipment and determination of their conformity to the specified requirements.
Infant ESP failure: ESP failure that occurred within 48 hours after the startup (including function test).
Item: Component, device, subcomponent, functional unit, equipment, or system that may be individually considered. (ISO 15551-1)
Primary Failed Item: The Failed Item responsible for the start the failure of the ESP System. (ISO 15551-1)
Protector: ESP Seal Section.
Primary failed item**:** Failed component within the ESP system responsible for initiating the failure of the ESP System. (ISO 15551-1)
Primary failed descriptor: Failure descriptor associated with the primary failed item. (ISO 15551-1)
Premature failure: ESP failure occurred during the target run-life specified in the contract.
Root-cause of failure: Fundamental reason of the failure.
Reason for Pull: The motive for the ESP System pull.
Root-Cause: The main reason of the failure that is determined during investigation.
Seals: Parts of ESP equipment designed to seal parts of ESP equipment.
Sealing mark: Mark that made immediately after assembly. Sealing mark is an evidence that the ESP Unit was not disassembled and there was no spontaneous turn-away of the shaft during operation. Sealing mark could have a form of one of letter: “I”, “X”, “A”, “N”, etc.

Shaft Settings: Shaft rotation, extension and/or deeping, condition of splines.
Teardown: The process of the equipment disassembly that includes measuring of specified characteristics, troubleshooting and completing the Teardown Report.
Troubleshooting: Identification of problems during Teardown.

Warranty period failure: ESP failure occurred after the target run-life specified in the contract, but before the end of the Factory warranty.
Warranty period: The period of the equipment operation during which the equipment is under warranty. The warranty period is specified in Technical Specifications, Product Certificates and Contracts. If the warranty period is different in the documents, consider the warranty period specified in the Contract.
AM: Asynchronous motor
BOH: Bolt on head
DIFA: Dismantle, Inspection and Failure Analysis
DHS: Downhole sensor
ESP: Electrical Submersible Pump
HSE: Health, safety and environment
IR: Insulation resistance
MLE: Motor lead extension
NCR: Non-Conformity Report
PMM: Permanent magnet motor
POOH: Pulling out of hole
RIH: Run in hole
RIG: Drilling derrick

DIFA Procedure is used along with Dismantling manual NLS-OPS-FS-MN-01 and corresponding Teardown procedures. DIFA Procedure describes additional actions during dismantling/teardown that are related to investigation of the Root-Cause of the failure. There are no links to the paragraphs of the dismantling/teardown procedures, but to make the DIFA Procedure clear, the following signs are used:

General signs:

– Visual inspection

– Measurements (all the type, including measurements by digital devices)

– Disassembly

– Take picture (Make video records, if the non-conformity detected could not be fully transmitted by the picture). Make pictures for any unusual event.

– Write down the corresponding result to Pull-Report / Teardown Report / Other document (depending on the Contract Requirements). Make records for any unusual event.

Warning signs:

– Radiation Hazard

– Electrical hazard

– Pay attention

– Pinch point

06. Responsibility

Location:

Country Manager:

- Ensures the fulfilment of DIFA procedure by Location.

DIFA Engineer / QA/QC engineer (or other specialist depending on the Location's structure)

NOTE | **If facility structure includes both a DIFA Engineer and a QA/QC Engineer, we share responsibilities. if facility structure includes only one, then the responsibilities of both are on one of the available position**

- Manages DIFA Process
- Leads the committee for inspection
- Schedules the Inspection
- Collects all the documents required for DIFA
- Analyzes documents before inspection (PIFA report, Quality Documents, Operating Documents, etc.)
- Collects and analyzes the results of inspection (Teardown reports, Quality Documents, etc.). Involves specialists under necessity.
- Fills DIFA Report
- Receives agreement of DIFA Reports (HQ Head of KPI control group) of failures caused by NOVOMET responsibility before sent to the Customer
- Uploads DIFA Report to the Corporate Portal
- Performs future activities according to the closed DIFA Process
- Provides additional information related to DIFA to HQ under request
- Enter the information into SL.
- Analyzes DIFA Results
- Analyzes DIFA Statistics
- Takes part in the future activities according to the closed DIFA Process (Quality Alert, CAPA Plan, etc. according to the approved procedures).
- Requests additional information related to DIFA Results

FS Representative (FS Manager, FS Engineer, FS Technician, etc. depending on the Location's structure)

- Performs dismantling of the equipment in the Field Site according to the corresponding dismantling procedure
- Follows DIFA Procedure to perform additional actions for the equipment subjected to DIFA
- Fills Dismantling report and Dismantling Check List
- Updates Weekly Report based on the received DIFA Results
- Communication with Customer in case of missing data/documents

OPS Manager

- Providing documents required for DIFA
- Appoints the participants of DIFA Committee
- Communication with Customer in case of missing data/documents (daily well flow rate; well flow rate for the last 3 days before failure; daily dynamic fluid level; dynamic level of the well for the last 3 days before failure; annulus pressure; manifold pressure; basic sediment & water; causes of well shutdown for the entire period of operation of ESP; etc.)
- Provide informing International QA/QC Manager HQ if Facility have received penalty by ESP failure.

WS Manager

- Providing documents required for DIFA

Inventory Representative (or other specialist depending on the Location's structure)

- Receives the dismantled ESP and moves it to the corresponding warehouse

NOTE | **Send the equipment to WS for inspection after DIFA Engineer approval only!**

WS Representative (WS Technician/ WS Engineer, etc. depending on the Location's structure)

- Under DIFA Process, reports to DIFA engineer
- Performs all the activities under control of DIFA Engineer
- Performs teardown according to the corresponding teardown process

DIFA Committee participants: Customer Representative / FS Representative / WS Representative / / QA/QC representative / Other*

- Participates in the committee for inspection and determination of the Root-Cause of the failure

*The list of participants is determined by DIFA Engineer based on the Contract requirements and the structure of Location. Other specialists could be involved to the Committee.

QA/QC Engineer Local

- Performs actions on the ESP Failure: NCR, Quality Alert, provide DIFA cased CAPA implementation
- Analyzes DIFA Results
- Analyzes DIFA Statistics
- Takes part in the future activities according to the closed DIFA Process (Quality Alert, CAPA, etc. according to the approved procedures).
- Requests additional information related to DIFA Results.

Finance representative

- Performs financial liabilities according to the Contract, if Customer sent a corresponding request.
- Provide informing International QA/QC Manager HQ if Facility have received penalty by ESP failure.

Warehouse Representative

- Moves the equipment subjected to DIFA to Workshop.
- Controls the dismantled equipment at the Warehouse

Application Engineer

- Provides the documents and information required for DIFA (Sizing report, Commissioning Report, Wells History, Recommendations, etc.)
- Draw up PIFA report using received information prior to make a decision on further ESP installation.

HQ:

International QA/QC Manager

- Participates in the determination of root cause of the failure (if it requires some in-depth investigation)
- To approve formal response to a Customer related to ESP failures.
- Deciding whether to create a quality alert and CAPA in regard to ESP failure
- To approve NC Reports of Novomet-Perm JSC and Novomet Supplier's products
- Analyze and present a consolidated failures data of the NOVOMET products to the Factory to improve product quality
- Analysis of ESP failure investigation system efficiency to increase effectiveness of QC
- Collection and consolidation of information about products quality during manufacturing and operation, presentation of consolidated data to the design, technological and other departments for their review, in order to develop measures to improve product quality.

Head of KPI control group

- Control, supervising and support during ESP failures investigation
- Participates in the determination of party in fault of the failure (if it requires some in-depth investigation)
- Analyzes DIFA Results/ DIFA Reports
- Analyzes and approves differences are applied to the DIFA Procedure by the Location (follow the form of procedure NLS-OPS-WS-P2-F8)
- Takes part in the future activities according to the closed DIFA Process (NCR, Quality Alert, CAPA Plan, etc. according to the approved procedures)
- Procedure review

Head of Suppliers quality control group

- Control, supervising and monitoring NCR data of the supplied products and services
- Preparation of conclusions on the compliance of the supplied products and services
- Assessment of the quality and effectiveness of existing suppliers and providers
- Control and support claims work with suppliers

NCR Team (NCR Leader, NCR Engineer)

- Analyzes DIFA Results
- Takes part in the future activities according to the closed DIFA Process (NCR, CAPA Plan, etc. according to the approved procedures).
- Requests additional information related to DIFA for NCR investigation

Technical Support Team

- Analyzes DIFA Results
- Analyzes DIFA Statistics
- Requests additional information related to DIFA Results

07. Main Stages of DIFA Process

7.1 DIFA Procedure includes minimum requirements for ESP failure investigation shall be implemented in Facility. Procedure describes general approach to Dismantling, Inspection and Failure Analysis: process steps, forms that should be filled, failure analysis overview. DIFA is aimed to find the Root- Cause of failure. The results obtained during DIFA are used to develop the actions for constant improvement of quality processes.

NOTE	Before implementation of DIFA Procedure, make sure that all the steps and forms correspond to the Customer's requirements and local law. If reasonable, the procedure in Location could have minor changes according to the Customer's requirements and local law or opportunity for improvement. All the changes shall be approved by HQ. DIFA Engineer performs the following actions to make changes in DIFA Procedure: If the necessity to change the DIFA Procedure caused by Customer's requirements and local law (for example, additional or changed form, additional steps, additional equipment) – DIFA Engineer make PFD. Head of KPI group control shall evaluate the PFD and make a decision of the necessity to change the DIFA Procedure as an opportunity for improvement, if necessary change the procedure globally.

7.2 Immediately after ESP Failure, FS Representative/Representatives performs the following actions:

- confirms the failure and determines the reason for pull
- downloads VSD Logs and provides them to DIFA Engineer.

AE draws up PIFA report using received information prior to make a decision on further ESP installation.

FS manager shall familiarize with PIFA report, sort out potential failure item, and provide execution of extra measurements during ESP dismantling.

7.3 Perform DIFA if one of the conditions are met:

1. Warranty case (DIFA is perform even if the Customer does not require it).
2. Non-warranty case, but the Customer requests for DIFA.
3. Non-warranty case, but DIFA is necessary to Location.
4. Non-standard cases of failure:
   - Breakdowns and turnouts of tubing by thread/by body.
   - Breakdowns and turnouts of ESP Units by bolt connections, by the housing body, by the threaded connections.
5. Supervised operating of equipment (pilot operating, trial operating in the field, ESP projects etc.).

If all the conditions are not met, it is acceptable not to perform DIFA.

NOTE	If the Customer does not need a report after completing the DIFA, include the results of DIFA to DIFA register table (Local ESP teardown register table).

7.4 Take the reason for Pull into consideration. The DIFA Process is similar for all the reasons for Pull, but it is necessary to pay attention to the possible reasons of failure depending on the reasons for Pull (see Annex 1).

There are four general reasons for Pull that requires DIFA:

- **Electrical (R-0, etc.)** – failure caused by insulation resistance by the system "Cable-Motor". Pay attention to electrical part of the ESP.
- **Flow** – failure caused by a lack /decrease of flow at the wellhead, including cases of leaking of the tubing hanger. Pay attention to the condition of housings, pump stages, tubing, shaft, operation conditions and proper shimming, condition of pump stages, bearings, shaft.
- **Pump stuck (ESP stuck)** – failure caused by no the ESP rotation (accompanied by an excess of the operating current above the maximum allowed). If the insulation resistance is found to be reduced to 0 MOhm or there is no "Y-point balance", the well stop is classified as Low resistance.
- **Non-standard cases of failure (fall of downhole equipment)** – fall downhole equipment involving the dismemberment of a tubing or ESP units during operation.

7.5 Immediately after ESP failure, FS representative/representatives/AE engineer perform actions in accordance with the Preliminary Inspection Failure Analysis procedure.

7.6 Immediately after ESP failure, DIFA Engineer collects all the information that could be used during failure investigation to preserve the evidence needed for failure analysis and root-cause determination. The reference list of documents presented below (during investigation may need additional data):

Document	When should the document be received
VSD Logs	Within 5 days after failure
Sizing report	Before Dismantling
Commissioning report	Before Dismantling
Product Certificates	Before Dismantling
Reports of ESP operating in well	Before Dismantling
Installation Report	Before Dismantling
Dismantling Report	After Dismantling
Weight indicator of RIG	After Dismantling (in case of detection of the ESP Units fall)
ESP Installation history (installation, pull, and failure reports from the same well)	Before Dismantling
Chemical treatment history	Before Dismantling
Information on well design (completion profile, wellbore profile, maximum dogleg severity)	Before Dismantling
Geological and technical actions history	Before Dismantling

* If any document is missing, DIFA Engineer requests the document from AE/FS/OPS Representative (depending on the type of document).

7.7 During inspection, DIFA Engineer determines the failed items, failure descriptors / category of failure for each of the failed items.

NOTE	Take into account that the failure could be caused by a number of causes. For this reason, follow all the steps of DIFA Procedure to determine all the failed items, failure descriptors and category of the failure.

> For example – even the burnout of lead wires was detected, it is necessary to disassemble and inspect all the components of ESP.

7.8 Based on the determined failure items, failure descriptors / category of failure, documents, etc., DIFA Engineer determines the primary failed item and primary failure descriptor.

7.9 DIFA Engineer analyzes all the received information and determines the root-cause of the failure.

7.10 DIFA Engineer receives internal and external agreement of DIFA Reports. If it is not agreed, DIFA Report is discussed and/or sent to rework.

7.11 QA/QC Engineer performs / provides information for future activities based on DIFA Results: NCR, Quality Alert, Warranty liabilities, updating Weekly Report, etc.

7.12 Main stages of DIFA Process are presented in the Figure 1.

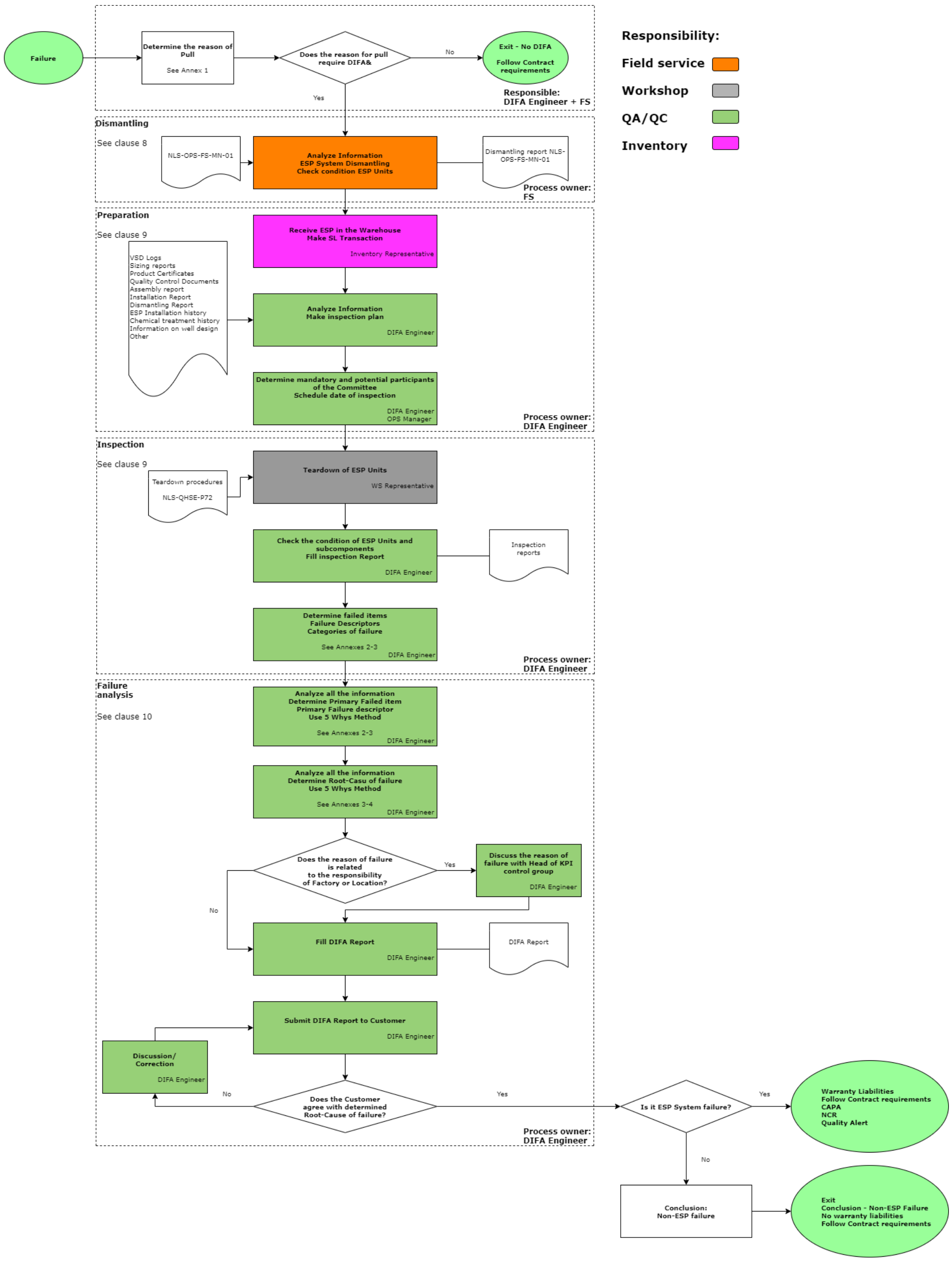


Figure 1. Main stages of DIFA Process

08. Dismantling

8.1 Dismantling is the first stage of DIFA Process. Information received during Dismantling is integral part of determining of the Root-Cause of failure.

8.2 Before Pulling, FS Representative prepares to Dismantling:
- Documents: Commissioning Report, Sizing Report, Product Certificates.
- Sends the notification on the ESP failure to Customer and to HQ by e-mail.
- Updates installation database.
- Updates SL data.
- Fills other documents depending on the Customer requirements

8.3 FS Representative performs Dismantling according to the manual NLS-OPS-FS-MN-01 and completes Pulling and Dismantling Reports (NLS-OPS-FS-MN-01).

NOTE	Make records and take pictures to provide the evidences for the failure analysis. Save ESP components (MLE, MLE Plug, etc.) to perform the detailed investigation. Do not clean the equipment during dismantling. Save the condition of the equipment for inspection.

8.4 According to results of Dismantling, FS Representative determines if it is necessary to prepare the Quality Alert. If the Quality Alert should be prepared, follow the procedure NLS-QHSE-P5.

8.5 After Dismantling, deliver the dismantled equipment to the warehouse.

During Dismantling, follow NLS-QHSE-P20 NORM

NOTE	For the steps with measurements, write down the values of the measured characteristics. Do not write valid/not valid

8.6 During Pulling and Dismantling, follow NLS-OPS-FS-MN-01. Pay attention to the steps described in the p. 8.7-8.32.

8.7 Disconnect the cable from junction box. Measure insulation resistance of the system Motor-Cable: Ph-Gnd, Ph-Ph (see Annex 5).

8.8 During dismantling of cable, collect and calculate all the CCCP, cable bands, MLE Guards.
If cable damage is detected, perform the following actions:
- identify the place and character of damage (indents, damages caused by clamps, etc.)
- mark the place of damage on both sides of the cable with marker or tape. Write down the number of tubing if possible.
- make picture of the damage with the table: Date, Well, Length from the motor side. Mark the side where the damage is detected (interior/exterior).
- make corresponding notes in Dismantling Report.

8.9 Check the drain valve position: on position / out of position.

8.10 Check upper sand trap for the presence of solids, scales, corrosion / erosion.

8.11 Check the condition of check valve for the presence of solids, scales, corrosion / erosion.

8.12 Check Discharge Pressure Sub, control line and fittings.

8.13 Check BOH for the presence of solids, scales, corrosion.

8.14 Check the condition of bolts connections on the flange connections.

8.15 Before start the Pump dismantling, check the shafts rotation of the complete ESP system.

8.16 Dismantling of Pump sections

8.16.1 To identify the cases of the shaft breaking/lock, Check the shaft rotation as follows:

- Check the shaft rotation of the whole ESP System
- Dismantle the pump section
- Check the shaft rotation of the dismantled pump section from the both sides.

8.16.2 Check the condition of housing, head and base (presence of washouts outside of housing and inside a head)

8.16.3 Check the pump sections for the presence of solids, scales, heating traces.

8.16.4 Check the condition of bolts connections on the flange connections

- corrosion and scales.
- make picture of the bolt condition or absence.

8.16.5 Check the condition of O-Rings on the flanges

8.16.6 Check the spline couplings: the splines presence, splines integrity and splines condition. After checking the coupling condition, put it back to the shaft.

8.16.7 For compression pumps, measure the width of the shims

8.16.8 Check the serials numbers of the pump sections.

8.16.9 Write down serial numbers of pump sections one by one.

8.17 Dismantling of Intake Device

General steps for each type of intake device

8.17.1 Check the shaft rotation

8.17.2 Check the condition of housing, head and base (presence of washouts inside a head).

8.17.3 Check the intake device condition:

- mechanical damages, corrosion, scales, heating traces
- solids on the head and base

8.17.4 Check the intake screen and/or inlets for the presence of solids, scales, deformations.

- the presence of intake screen
- contamination level (plugged totally/plugged partially /not plugged)

8.17.5 Check the condition of nuts connections on the flange connections

- corrosion and scales.
- make a picture of the bolt condition or absence.

8.17.6 Check the spline couplings: the splines presence, splines integrity and splines condition. After checking the coupling condition, put it back to the shaft.

8.17.7 Check and write down the serials numbers of the intake

8.18 Dismantling of Gas Separator (GS) and Advanced Gas Handler (AGH) (in the presence)

Check the condition as for the intake. 8.17.1-8.17.7 plus the following:

- presence of washouts outside of housing and inside a head
- vents (gas-escape holes)

8.19 Dismantling of Slotted Screen Pump Intake (SPI) and Redundant Intake (in the presence)

Check the condition as for the intake. 8.17.1-8.17.7 plus the following:

- filter elements for the presence of mechanical damages, deformation.

Check the condition of wire turns.

8.20 Dismantling of Filters (in the presence)

General steps for each type of filter

8.20.1 Check the condition of housing, head and base

8.20.2 Check the condition of bolts connections on the flange connections

- corrosion and scales.
-make a picture of the bolt condition or absence.

8.20.3 Check the spline couplings: the splines presence, splines integrity and splines condition. After checking the coupling condition, put it back to the shaft.

8.20.4 Check and write down the serial numbers of the filter.

8.21 Dismantling of Slotted Filter (SFD)

Check the condition as for filter: 8.17.1-8.17.4 plus the following:

Check the condition of filter elements

- mechanical damages, deformation, deviation of wire turns (for SFD only), solids and scales

8.22 Dismantling of Downhole Gravitation Filter (GFD)

Check the condition of filter elements

- mechanical damages, deformation, deviation of wire turns solids and scales

Check the presence of scales in the container of GFD

Check the condition of seal unit.

8.23 Dismantling of Scale Preventers (SP)

Check the condition of housing

- presence of corrosion and deformation
- check the value of inhibitor

8.24 Dismantling of Protector

8.24.1 Check the shaft rotation, presence of mechanical damages, corrosion, scales, heating traces, presence and condition of plugs

8.24.2 Close vent-holes.

8.24.3 Check the condition of housing, head and base (presence of washouts inside a head), presence the scales inside the head.

8.24.4 Check the presence of reservoir fluid by opening of the plugs according to NLS-OPS-FS-MN-01.

8.24.5 If the reason for Pull is R-0: Perform pressure test of the system DHS (in the presence) – Motor – Protector – MLE according to the manual NLS-OPS-FS-MN-01.

- If the system has leakage, determine the place of leakage.
- Do not disconnect protector from the motor (if possible).

8.24.6 Check the condition of nuts connections between intake and protector on the flange connections

- corrosion and scales.
- make a picture of the bolt condition or absence.

8.24.7 Check the condition of O-Rings on the flanges

8.24.8 Check the spline couplings: the splines presence, splines integrity and splines condition. After checking the coupling condition, put it back to the shaft.

8.24.9 Check serials numbers of the protector

8.24.10 Write down serial numbers of protector sections one by one.

8.25 Dismantling of the system: Motor and Cable

!!! In case of PMM checking, pay attention that the PMM could give an electric shock!!!

8.25.1 Check the shaft rotation (in case of PMM checking it is allowed that shaft rotates with intermittent resistance)

8.25.2 Check the condition of oil

8.25.3 Check the condition of MLE Pothead

- presence of corona discharge traces
- check the presence of cable pulled out from the pothead (armor overlap might be violated more than 2mm)

In this case it is necessary to get the logs of RIG weight indicator recording system.

8.25.4 Check the condition of housing

- mechanical damages, heating traces, corrosion, scales

8.25.5 If the system DHS (in the presence) – Motor – Protector – MLE has leakage do not disconnect the MLE from the motor. Band the MLE cable to the motor head 4.92 ft (0.15 m) from the MLE Plug. Cut the MLE from the distance 1.6 ft (0.5 m) from the MLE Plug. To protect the cable during transportation to WS, attach the cable to the motor head with band.
Measure the insulation resistance of the motor with MLE: Ph-Gnd, Ph-Ph (see Annex 5).

!!! Avoid sparks, do not use catwalks for electrical measurements of motors!!!

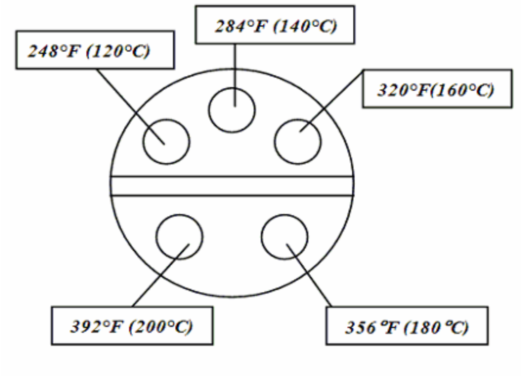
8.25.6 Check the condition of nuts connections on the flange connections of the Motor

- corrosion and scales.
- make a picture of the bolt condition or absence.

8.25.7 Check the presence and condition of the plugs in check valves.

Check a thermal indicator:

Define the maximum operated motor temperature by thermal indicator following to the scheme:



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When indicated temperature is reached, special alloy is melted from thermal indicator housing. (Temperature accuracy is ±9 ºF (±5°C))

8.25.8 Check the insulation resistance of the cable: Ph-Gnd, Ph-Ph (see Annex 5).

8.25.9 Check the serial numbers of the motor.

8.25.10 Write down serial numbers of motor sections one by one.

8.25.11 Check the motor oil from the lower valve in the motor base for the presence of reservoir fluid. Make picture. Make corresponding notes in Dismantling Report.

8.26 Downhole Sensor (DHS)

Do not disconnect the DHS from the motor

8.26.1 Check the DHS condition:
- damages, heating traces, scales.
- connection between motor and DHS

8.26.2 Check the condition of nuts connections on the flange connections of the Motor
- corrosion and scales
- make a picture of the nuts condition or absence.

8.26.3 Check the additional equipment located below the DHS (if applicable)

8.26.4 Check and write down serial number of DHS.

8.27 Dismantling of Shroud (in the presence)

Check the shroud condition
- shroud lock, neck, housing and thread for the presence of solids, deformation and scales.

8.28 Y-Tool System (in the presence)

8.28.1 Check the Bypass Tubing condition:
- mechanical damages, corrosion, contamination on the threads and surfaces.

8.28.2 Check the Y-Block assembly condition:
- mechanical damages, cracks, mechanical damages, deformation, corrosion, contamination.

8.28.3 Check the bypass clamps and fasteners condition:
- mechanical damages, corrosion, deformation.

8.28.4 Check the blanking plug / or logging plug condition

8.28.5 Check the Tailpipe condition.

8.29 Dual System (in the presence)

8.29.1 Check the Y-Block assembly condition: 👁

- cracks, mechanical damages, corrosion, contamination

8.29.2 Check the condition of threads (suctions, tubes, adapters): 👁

- damages, cracks, mechanical damages, corrosion, contamination

8.29.3 Check the condition of bypass clamp: 👁

- mechanical damages, deformations, corrosion

8.29.4 Check separately each ESP and packer equipment 👁

8.30 Dual System (in the presence)

8.30.1 Check the fitting tool: 👁

- Condition of threads (presence of mechanical damages, deformation, corrosion).
- Condition of seal elements (presence of cuttings, deformation)
- Condition of seal elements stretchability

8.30.2 Check the condition of disconnectable clutch: 👁

- Condition of threads (presence of mechanical damages, deformation, corrosion).
- Condition of housing (presence of mechanical damages, deformation, corrosion, scales)

8.31 Inverted ESP Systems (in the presence)

Check the condition of the housings, tubes, adapters (presence of mechanical damages, deformation, corrosion). 👁

NOTE | Inverted ESP shall be checked as a conventional ESP.

8.32 Actions after dismantling

8.32.1 Check the presence and completeness of all the pulling and dismantling documents ✎

Put all the damaged parts to the separate bags. Specify the following information on the bag:

Oilfield
Well
ESP Serial number
Dismantling date

8.32.2 Put the corresponding spline couplings, and shipping caps to each ESP Unit 🔧

8.32.3 Deliver the dismantled equipment to teardown.

09. Inspection

9.1 The dismantled ESP is sent to the warehouse.

After receiving the equipment, follow NLS-QHSE-P20 NORM

9.2 Inventory Representative receives the equipment, informs DIFA Engineer.

9.3 Warehouse Representative controls the dismantled equipment at the Warehouse / Location, identifies the equipment subjected to inspection and attaches the tag "Subjected to DIFA".

9.3.1 If Supervised equipment was sent to the Warehouse, Inventory Representative attaches the tag "Supervised equipment" and informs DIFA Engineer.

9.4 DIFA Engineer starts preparation to inspection:

- analyzes documents according to the p.7.6: non-routine events. Description of VSD Logs Analysis presented in Annex 6.

- determines (based on the analysis) the ESP units that should be subjected to a more detailed inspection.

- schedules the DIFA with Customer (DIFA should be performed no later than three days from the moment of arrival at the service base).

OPS Manager determines the participants of inspection committee:

Mandatory participants	**DIFA Engineer (leader)** **Workshop Representative** (Workshop Manager / Workshop Supervisor) **Customer Representative*** (under approval, the inspection could be performed without Customer Representative)
Potential Participants	**Field Service Representative** (Field Service Manager / Field Service Supervisor) **QA/QC Representative** **External Supplier** **Other** (depending on the reason for Pull and Location Structure)

9.5 Warehouse Representative moves the equipment subjected to DIFA to Workshop.

Inspection consists of two parallel processes:

- Disassembly.
- Troubleshooting.

9.6 WS Representative performs disassembly of equipment according to the corresponding teardown procedure.

9.7 DIFA Engineer manages Inspection process, performs/controls of performing of the actions described in the p.9.11-9.25, and fills the teardown reports (forms NLS-QHSE-P72-F1 – NLS-QHSE-P72-F6).

NOTE Make sure that the equipment has an ambient temperature (the temperature in the Workshop).

9.8 During inspection, DIFA Engineer determines the condition of ESP Units and subcomponents. If an ESP Unit/Subcomponent can no longer perform it's required function, DIFA Engineer marks it as failed item (see Appendix 2).

9.9 For each failed items, DIFA Engineer determines Failure Descriptor/Descriptors and Categories of the Failure Descriptors (see Appendix 3). This information is valuable for Root-Cause determination.

NOTE

Failure descriptor – is an apparent, observed cause of failure (ISO 15551-1). In other words, it is a symptom/perceptible sign/consequence of the failure, but it is not the Root-Cause of the failure. For example: Pump Shaft is broken.

Failed Item	Subcomponent	Failure descriptor	Category of failure
Pump	Shaft	Broken	Mechanical

Broken shaft itself could not be the Root-Cause of the Failure. During Failure Analysis, it is necessary to determine what exactly led to the shaft damage.

9.10 DIFA Engineer collects all the inspection documents and completes the documents set for Failure analysis.

9.11 Motor inspection

- **!!!In the case of PMM take off mechanical watch or put them far from the magnets!!!**
- **During extraction of rotor stack, avoid contact of rotor stack and any metal parts.**
- **Keep your hands! Rotor stacks could suddenly magnetize to each other and pinch your finger**
- **Be careful with metal parts, keys, calipers, etc. - they may suddenly magnetize onto the rotor package**

NOTE During inspection, fill Motor Teardown Report: NLS-QHSE-P72-F1

9.11.1 Check description and serial number.

9.11.2 Check the condition of housing, head and base:

- mechanical damages, corrosion, heating traces, solids, etc.
- condition of coating: damages, scratches, cracking.
- condition of painting.

9.11.3 Check the presence and integrity of sealing mark.

9.11.4 Check the presence and condition of shipping caps.

9.11.5 Measure the insulation resistance of the motor with DHS and the MLE Plug.

Select the voltage in accordance with the DHS Product Certificate.

9.11.6 Perform air pressure test of the system DHS (in the presence) – Motor – MLE Plug (in the presence): 5-3-5 (5 kgf/cm^2 – 3 min – 5 kgf/cm^2).

In the case of leakage, determine the place of leakage.

(It is allowed to perform oil pressure test of the motor, but oil samples should be taken before pressure test).

If the well fluid is detected in the motor, at the same time there is no leak and pressure drop during pressure test of the motor, it is necessary to do the following:

- unscrew plug of check valve

- check the lead gasket condition
- check ball in the valve at presence of foreign materials.

9.11.7 Disconnect the DHS according to the corresponding teardown procedure.

NOTE	During disassembly, check the condition of all the O-Rings (degree of elasticity, damages, cracks, contamination under O-Rings, etc.) Check the presence and condition of all the lead washers.

NOTE	During inspection, fill DHS Teardown Report: NLS-QHSE-P72-F2. After DHS inspection, move it to the corresponding storage area.

9.11.8 Check description and serial number.

9.11.9 Check housing condition

- mechanical damages, corrosion, heating traces, solids.
- condition of coating: damages, scratches, cracking.
- condition of painting.

9.11.10 Measure insulation resistance of the DHS

Select the voltage in accordance with the DHS Product Certificate.

9.11.11 Check the DHS operability:

- Connect the DHS to the Surface Panel (NSP).
- Start-up the system.

Check the presence and accuracy of the VSD data.

9.11.12 Check the condition of feed-through:

- damages and melting

9.11.13 Check the condition of connector parts

- damages and deformations, burnouts

9.11.14 Take oil sample from the bottom of the motor and measure dielectric strength according to the approved procedure and the following requirements:

- Prepare a container to take oil samples.
  The container should comply to the following requirements:
  - designed to taking of samples.
  - clean, dry and made by transparent plastic. It is preferable to use containers that do not decompose from the motor oil and protect the container from direct sunlight.
- Flush the reservoir with clean oil. Set the reservoir under the motor-DHS jointing.
  Take care and prevent possible contamination of the oil sample.
- Take oil sample. Make corresponding labels for identification.
  Utilize of the oil sample after testing by accordance method.
- Perform visual inspection of oil.
  Check the oil color. Check the presence of solids, reservoir fluid, contamination, presence of metal chips, evidences of heating.

NOTE	In the presence of reservoir fluid inside the motor, it is allowed to not test the motor oil for oil dielectric strength.

NOTE	If a reservoir fluid was detected in the motor, check leak-proofness for each pressure test valve (leak-proofness of the system valve-plug).

- The oil sample shall become stabilized for 30 minutes. Make sure that the oil sample has an ambient temperature (the temperature in the Workshop).
- Measure oil dielectric strength according to the approved procedure.

9.11.15 Measure the insulation resistance of the motor without DHS according to Teardown Procedures of the Motor.

9.11.16 Continue disassembly. Disconnect the MLE Plug.

9.11.17 Measure the insulation resistance of the MLE Plug (Ph-Gnd, Ph-Ph). See Annex 5

NOTE	In the case of R-0 of the motor, measure the insulation resistance after each stage of motor disassembly until the location of R-0 is not detected.

9.11.18 Check the condition of the MLE plug:
- integrity, damages, cracks, burnouts, melting
- check the condition of socket connectors

9.11.19 Perform pressure test of the MLE Plug

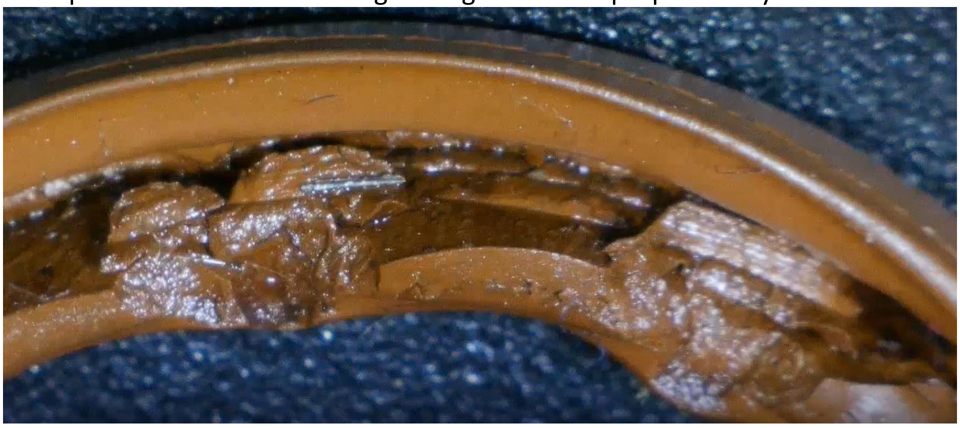
9.11.20 Check the shaft:
- Check the shaft rotation
- measure shaft settings according to Design Documentation (or corresponding assembly procedure)
- Check the condition of shaft splines
- Check the condition of splines of coupling.

9.11.21 Continue disassembly. For Upper section check the presence of axial displacement of motor socket. (Axial displacement of motor socket is not allowed). Disconnect the motor socket.

9.11.22 Check the condition of motor socket:
- presence of chippings, cracks, burnouts
- condition of O-Rings

NOTE

Example of motor socket O-Ring damage due to improper ESP system installation.



- condition of lead wires and terminals (damages, cracks, burnouts, etc.)
- condition of lead terminal sleeves

9.11.23 Measure the insulation resistance of the motor without motor socket.

9.11.24 Continue disassembly. Check the condition of runner, downthrust bearing, bearings:

- presence of wear, destruction, melting, scratches.

9.11.25 Perform visual inspection of Y-point, neutral wire, electrical connectors:
- presence of burnouts, cuttings, ruptures
- check the elastic state of the insulation layer

9.11.26 Check filter condition:
- presence of contamination

9.11.27 Continue disassembly. Extract the rotor. Measure the insulation resistance of the stator without rotor (if the stator R-0), measure polarization index.

9.11.28 Check the condition of rotor stack:
- color, dimension changes, presence of well fluid's tears, hits, wear, lamination, polarity, burnouts.

9.11.29 Check the condition of bearings, bearing bushings:
- annealing color
- alignment of the bearing bushings with the shaft holes
- wear of the coating of bearings
- rotor thermal clearance
- one-sided wear;

In the case of wear traces, estimate the degree wear:
Measure ID of bearings, OD of bearing sleeves.

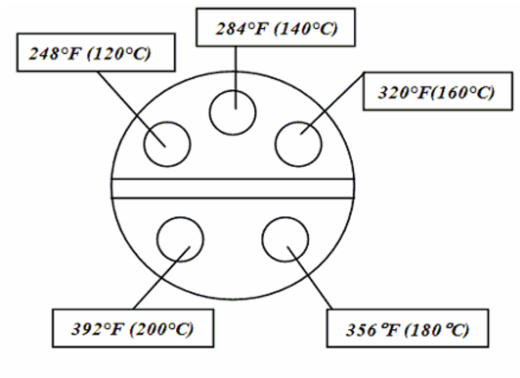
9.11.30 Check the condition of key, keys slot, grooves for lock rings:
- presence of destruction, twisting, heating traces.

9.11.31 Check the shaft condition:
- presence of destruction, twisting, heating traces, purity of holes in the shaft.

DIFA Engineer takes the decision if it is necessary to measure the shaft straightness.

9.11.32 Check a thermal indicator:

Define the maximum operated motor temperature by thermal indicator following to the scheme:



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When indicated temperature is reached, special alloy is melted from thermal indicator housing. (Temperature accuracy is ±9 ºF (±5°C))

NOTE | In the case of tandem motor inspection, perform the same actions except for the paragraphs of DHS inspection

9.12 Inspection of the DHS, located in pump discharge

NOTE | During inspection, fill DHS Teardown Report: NLS-QHSE-P72-F2.
After DHS inspection, move it to the corresponding storage area.

Perform the following actions for DHS, located at pump discharge:

9.12.1 Check the condition of the control line:
- damages, check the condition of connectors

9.12.2 Measure resistance between the ends of control line using multimeter

9.13 Protector inspection

NOTE | During inspection, fill Protector Teardown Report: NLS-QHSE-P72-F3

Pay attention for inspection of the protector, if there was detected the reservoir fluid inside the motor.

Do not disassemble tandem modular protector before pressure test

9.13.1 Check the description and serial number.

9.13.2 Check housing condition:
- mechanical damages, corrosion, heating traces, solids
- condition of coating: damages, scratches, cracking
- condition of painting.

9.13.3 Check the presence and integrity of sealing mark.

9.13.4 Check the presence and condition of shipping caps.

9.13.5 Perform air pressure test:
- bags at 2 kgf/cm^2 – 5 min
- joints at 5 kgf/cm^2 – 5 min.

NOTE | If manometers readings changed, it is necessary to detect the place of leakage. If the place of leakage is not detected, increase the pressure to the required value and wait the specified time. These actions are required to mitigate the risk to classify leak-proof protector as protector with leakage.
In case of failed pressure test, check if the mechanical seals were installed correctly before lock ring is dismantled.

If the leakage is detected, stop pressure test.
Do not wait 5 minutes. Rotation of the shaft is not required.

9.13.6 Check the shaft:
- Check the shaft rotation
- measure shaft settings according to Design Documentation (or corresponding assembly procedure)
- Check the condition of shaft splines

- Check the condition of splines of coupling.

9.13.7 Consequently, from up to down, according to teardown procedure, remove plugs one by one. Take oil samples.

9.13.8 Take samples of oil from the corresponding holes from bags. If it is not possible to get oil, cut carefully the bag and take the oil sample.

9.13.9 Check the oil condition:

- presence of reservoir fluid, solids, color, transparence.

NOTE	If there is detected the presence of reservoir fluid, do not measure oil dielectric strength

9.13.10 Measure oil dielectric strength according to the approved procedure.

9.13.11 Continue disassembly. Consequently, from up to down, perform pressure test of mechanical seals:

- mechanical seals at 2 kgf/cm^2 – 5 min.

Time to time push and rotate shaft during mechanical seals pressure test.

9.13.12 Check operability of relief valves: opening and closing pressure.

9.13.14 Check the presence and condition of O-Rings:

- mechanical damages, stretchability, color.

9.13.15 In case of failed pressure test, check if the mechanical seals were installed correctly before lock ring is dismantled.

Check the condition of mechanical seals:

- wear
- presence of cracks, chippings
- stretchability of bellows and springs condition.

9.13.16 Continue disassembly. Check the condition of labyrinths:

- presence of reservoir fluid, mud, asphaltenes, paraffins and corrosion

9.13.17 Continue disassembly. Check the condition of bandings and bags:

- presence of damages, cracks, stretchability, contamination, etc.

9.13.18 Continue disassembly. Before disassembly of runner, check if the upthrust bearing was installed correctly.

Check the condition of runner, upthrust and downthrust bearings, bearing sleeves:

- presence of wear, melting and destruction.

In the case of wear traces, estimate the degree of wear.

DIFA Engineer takes decision if it is necessary to measure ID of bearings, OD of bearing sleeves.

9.13.19 Check filter condition:

- presence and form of contamination.

9.13.20 Check the condition of shaft and keys.
- presence of destruction, twisting, scratches, heating traces.

9.14 Inspection of Pump sections

NOTE	During inspection, fill Pump Teardown Report: NLS-QHSE-P72-F4

Perform the following actions for each pump section.

9.14.1 Check the description and serial number.

9.14.2 Check the condition of housing, head and base, treaded and flange connection:
- mechanical damages, corrosion, heating traces, solids
- condition of coating: damages, scratches, cracking.
- condition of painting.

9.14.3 Check the presence and integrity of sealing mark.

9.14.4 Check the presence and condition of shipping caps.

9.14.5 Check the shaft:
- Check the shaft rotation
- measure shaft settings according to Design Documentation (or corresponding assembly procedure)
- Check the condition of shaft splines
- Check the condition of splines of coupling.

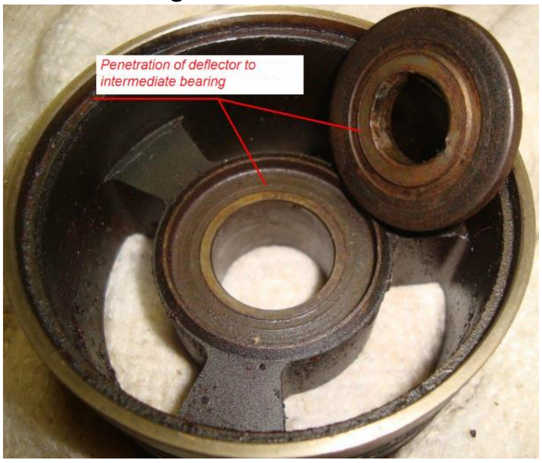
NOTE	If the shaft is broken, or splines are twisted, perform the following actions: Extract the pump stages from the housing. Do not interchange the seating of the pump stages. Put the top and bottom stages from the place of the shaft broken. If the shaft broken located in the place of the installation of intermediate bearing, put all the parts of the intermediate bearing and the nearest stages. During disassembly, perform visual inspection of each pump stage, each bushing.
NOTE	During disassembly, check condition of all the O-Rings (damages, cracks, stretchability, contamination under O-Rings, etc.)

9.14.6 Continue disassembly. Check the condition of upper bearing.

9.14.7 Continue disassembly. Check the condition of pump stages:

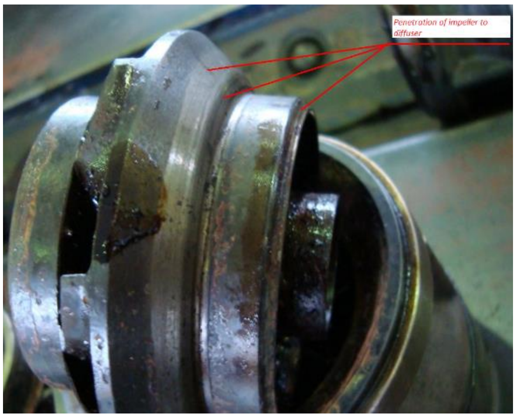
NOTE	During disassembly, follow corresponding teardown procedure depending to the Pump design (FLT, SCMP, CMP). **Pay attention to the following (depending of the pump design):** **For FLT, SCMP Pumps** Check impeller hubs, bearing bushings, shaft protection sleeves - locking, bents **For CMP Pumps** For pumps with washers: - wear of lower and middle washers,

- penetration of deflector to intermediate bearing



For pumps with hydraulic lock/labyrinth:

- penetration of impeller to diffuser



These evidences of the stages wear for pumps of CMP design indicate improper shimming during installation and/or improper ESP sizing.

9.14.8 Check impellers condition 🔧 👁:
- condition of washers.
- condition of key, key slot, impeller hub: wear, one-sided wear, damages.
- damages, washouts, corrosion, scales, solids, contamination, plugging.

9.14.9 Continue disassembly. Check diffusers condition 🔧 👁:
- condition of hubs and inner hole (wear, one-sided wear, damages).
- damages, washouts, corrosion, scales, solids, contamination, plugging.

9.14.10 Check the condition of upper and lower washers: 👁
- presence of wear, contamination, solids.

In the case of wear of washers, estimate wear depth (in mm). ✎

9.14.11 Continue disassembly. Check the condition of shaft and key. 🔧 👁
- presence of destruction, twisting, heating traces, radial wear, one-sided wear.

9.14.12 DIFA Engineer takes decision if it is necessary, take samples of solids and scales for a laboratory tests. 👁

9.15 Inspection of intake devices

NOTE | During inspection, fill Teardown Report for Intake Devices: NLS-QHSE-P72-F5

General actions for all the intake devices:

9.15.1 Check the description and serial number.

9.15.2 Check the condition of housing, head and base, treaded and flange connection:
- mechanical damages, corrosion, heating traces, solids.
- condition of painting.

9.15.3 Check the presence and integrity of sealing mark.

9.15.4 Check the presence and condition of shipping caps.

9.15.5 Check the shaft:
- Check the shaft rotation
- measure shaft settings according to Design Documentation (or corresponding assembly procedure)
- Check the condition of shaft splines

9.15.6 Check the condition of bearing bushings :
- wear, one-sided wear, damages.

9.15.7 Check the condition of splines of coupling.
- presence of wear, mechanical damages.

Check the condition of pins and splines

NOTE | During disassembly, check all condition of all the O-Rings (damages, cracks, contamination under O-Rings, etc.)

9.16 Multiphase pump inspection and teardown

Check as intake 9.15.1-9.15.7 plus the following:

9.16.1 Continue disassembly. Check impellers condition :
- condition of washers. Wear of textolite washers could be caused by shaft compression.
- condition of key, key slot, impeller hub: wear, one-sided wear, damages.
- damages, washouts, corrosion, scales, solids, contamination, plugging.

9.16.2 Continue disassembly. Check diffusers condition :
- condition of collars and inner hole (wear, one-sided wear, damages).
- damages, washouts, corrosion, scales, solids, contamination, plugging.

9.16.3 Check the condition of upper and lower washers:
- presence of wear, contamination, solids.

In the case of wear of washers, estimate wear depth (in mm).

9.16.4 Continue disassembly. Check bearings condition:
- presence of wear, damages, cracks, contamination, scales.

9.16.5 Check the condition of shaft and key.
- presence of destruction, twisting, heating traces, radial wear, one-sided wear.

9.17 Gas Separator (GS) and Advanced Gas Handler (AGH) inspection and teardown

Check as intake 9.15.1-9.15.7 plus the following:

9.17.1 Check the condition of vents (gas-escape holes).

9.17.2 Check the condition of intake screen, head and base.

- presence of the screen;
- presence of solids on the screen, contamination.

9.17.3 Continue disassembly. Check the condition of shaft protective sleeve and operative parts

- presence of wear, one-sided wear and washouts.

9.17.4 Continue disassembly. Check bearings condition.

- presence of wear, one-sided wear, damages, chippings, cracks, contamination and scales.

9.17.5 Check the shaft and key condition.

- presence of destruction, twisting, heating traces, radial wear, one-sided wear.

9.18 Inspection and teardown of filters

General actions for all the filters:

9.18.1 Check description and serial number.

9.18.2 Check housing condition:

- mechanical damages, corrosion, heating traces, solids
- condition of coating: damages, scratches, cracking
- condition of painting.

9.18.3 Check the presence and integrity of sealing mark.

9.18.4 Check the presence and condition of shipping caps.

9.18.5 Check the shaft:

- Check the shaft rotation
- measure shaft settings according to Design Documentation (or corresponding assembly procedure)
- Check the condition of shaft splines

9.18.6 Check the condition of splines of coupling.

- presence of wear, mechanical damages.

Check the condition of pins and splines.

NOTE	During disassembly, check all condition of all the O-Rings (damages, cracks, contamination under O-Rings, etc.)

9.19 Inspection and teardown of Screen Pump Intake (SPI)

Check as filter: 9.18.1-9.18.5 plus the following:

9.19.1 Continue disassembly. Check the condition of filter elements:

- presence of mechanical damages, deformation, deviation of wire turns
- presence of solids and scales.

9.19.2 Continue disassembly. Check bearings condition:

- presence wear, damages, chippings, cracks, contamination and scales.

9.19.3 Check the shaft and key condition.

9.20 Inspection and teardown of Downhole Slotted Filter (SFD) and Downhole Gravitation Filter (GFD)

Check as filter: 9.18.1-9.18.6 plus the following.

9.20.1 Check the condition of filter elements:

- presence of mechanical damages, deformation, deviation of wire turns

- presence of solids and scales.

9.20.2 Continue disassembly. Check bearings condition:

- presence wear, damages, chippings, cracks, contamination and scales.

9.21 Inspection and teardown of slotted screen pump intake (SSPI)

Check as filter: 9.18.1-9.18.5 plus the following:

9.21.1 Check oil condition:

- presence of reservoir fluid, solids. Check the oil color and transparency.

9.21.2 Measure the oil dielectric strength according to the approved procedure.

9.21.3 Continue disassembly. Check support condition:

- wear, destruction.

9.21.4 Continue disassembly. Check bearings condition:

- wear, destruction.

9.21.5 Check other SSPI parts condition:

- wear.

9.21.6 Continue disassembly. Check the shaft condition:

- deformation, key slot wear, slot ring deformation, lock ring deformation, cracks on the split shaft.

9.21.7 Check the axial displacement of the shaft.

9.22 Inspection and teardown of cable line

NOTE	During inspection, fill Teardown Report for Cable: NLS-QHSE-P72-F6

9.22.1 Review all the documents related to the cable line. Check in the documents (see pull report) the presence of cable splicing and damages.

If R-0 of cable line (MLE/Main cable) is detected during inspection, and there are no visible mechanical damages and burnouts, **do not rewind the armor**.
Before rewinding, check if the cable is under warranty. In this case proceed in accordance with the requirements of the complaints section of the Contract.

9.22.2 Perform electrical measurements of the cable line: Continuity, Insulation resistance (Ph-Gnd, Ph-Ph). See Annex 5.

NOTE	During electrical measurements, follow Annex 5: measure continuity, Insulation resistance (Ph-Gnd, Ph-Ph), current leakage for each of inspected parts

9.22.3 Rewind MLE and check its condition: damages, insulation integrity, etc. Cut the MLE with splicing on the distance 1 m from the splicing to main cable.
Perform electrical measurements separately for MLE + splicing and cable. Detect the place of R-0: MLE + splicing or cable.

When the part with R-0 is detected, perform its inspection.

NOTE	Pay attention to cable splicing and places of damages. Perform the actions described in the p.9.22.4-9.22.6 till the location of R-0 is detected

If R-0 in MLE length:

9.22.4 Rewind MLE till the detection of damage.

1. Check the condition of armor: corrosion, mechanical damages, bents, dents.
2. Carefully remove the armor from the place of damage.
3. Check the condition of insulation of conductors: melting, breakdown, damages, displacement of cable conductors.
4. If there is R-0 for the conductor, cut the damaged part. Perform electrical measurements for the both parts of MLE. .
5. In case of R-0 of the rest part MLE continue inspection till the location of R-0 is detected.

If R-0 in the main cable length:

9.22.5 Rewind the cable till the detection of damage/splicing.

1. Detect the location of damage.
2. Check the condition of armor: corrosion, mechanical damages, bents, dents.
3. Carefully remove the armor from the place of damage.
4. Check the condition of insulation of conductors: melting, breakdown, damages, displacement of cable conductors.
5. If there is R-0 for the conductor, cut the damaged part. Perform electrical measurements for the both parts of the cable. .
6. In case of R-0 of the rest part (cable on the cable reel) continue inspection till the location of R-0 is detected.

9.22.6 Actions for cable splicing (including the splicing of MLE and cable):

1. Cut the splicing.
2. Carefully remove the armor from the end of the splicing. Carefully rewind insulation tape.
3. Perform electrical measurements of the splicing and the rest part (cable on the cable reel)
4. In case of R-0 of the splicing, check its condition: damages, insulation integrity, etc.
5. In case of R-0 of the rest part (cable on the cable reel) continue inspection till the location of R-0 is detected.

9.23 Inspection and teardown of Shroud

The shroud inspection and teardown is performed in the case of the presence of shroud and Customer's approval/request.

Check the shroud clamper condition for presence of solids, deformations, scales.

9.24 Inspection and teardown of Y-Tool system

9.24.1 Check the description and serial number

9.24.2 Check housing condition

- mechanical damages, corrosion, heating traces, solids,
- condition of painting.

9.24.3 Check the presence and integrity of sealing mark

9.24.4 Check the presence and condition of shipping caps

9.24.5 Check the Bypass tubing: condition of threads and surface for the presence of mechanical damages, deformations, corrosion, contamination

9.24.6 Check Y-block condition

- presence of damages, cracks, mechanical damages, deformations, corrosion, contamination.

9.24.7 Check O-Rings condition

9.24.8 Continue disassembly. Check blanking plug (or logging plug) condition

- presence of damages, cracks, mechanical damages, deformations, corrosion, contamination

9.24.9 Continue disassembly. Check fasteners and bypass clamps condition (threads and surfaces):

- presence of mechanical damages, deformations, corrosion

9.25 Inspection and teardown of Dual system

9.25.1 Check the description and serial number

9.25. 2 Check housing condition

- mechanical damages, corrosion, heating traces, solids,
- condition of painting.

9.25.3 Check the presence and integrity of sealing mark

9.25.4 Check the presence and condition of shipping caps

9.25.5 Check the shaft settings

9.25.6 Check the condition of Y-Block assembly:

- presence of damages, cracks, mechanical damages, corrosion, contamination

9.25.7 Check the condition of threads of suctions, tubes, adapters

- presence of damages, cracks, mechanical damages, corrosion, contamination

9.25.8 Check the condition of threads of the ESP Slide Unit

- presence of damages, cracks, mechanical damages, corrosion, contamination

9.25.9 Check O-Rings condition

9.25.10 Continue disassembly. Check bypass clamps condition (threads and surfaces):

- presence of mechanical damages, deformations, corrosion

10. Failure analysis

Abstract	Failure usually accompanied by a combination of consequences: a number of failed ESP Units/Subcomponents, a number of Categories of failure (Electrical, Material, Mechanical, External). During Failure Analysis, it is necessary to determine general events that led to ESP failure: • Primary failed item – the Failed Item responsible for the start the failure of the ESP System, i.e. root failed item in the sequence of interrelated events that lead to an ESP failure (ISO 15551-1). • Root-Cause of failure – fundamental reason of the failure, i.e. the deepest cause of the failure that led to the observed symptoms of the failure (ISO 15551-1).

- 10.1 To determine Primary failed item and Primary Failure Descriptor (see Annexes 2-3), DIFA Engineer analyzes all the information received before and during inspection: documents, findings (symptoms of the failure), depending on the determined Failed Items, Failure Descriptors, Categories of failure. For determination of the Primary failed item use 5-Whys Method (See Annex 7) or other methods of Root-Cause Analysis.
- For Electrical category: analyze findings related to the supply and transmission of electrical power in more detailed.
- For External category: analyze findings related to external events or substances in more detailed (including results of reservoir fluid analysis).
- For Material category: analyze findings related to physical characteristics of the material in more detailed (including oil samples if necessary).
- For Mechanical category: analyze findings related to mechanical characteristics in more detailed (force, pressure, torque, temperature, etc.)

10.2 When the Primary failed item and Primary Failure Descriptor are determined, DIFA Engineer determines the Root-Cause of Failure. Root-Cause determination usually requires some in-depth investigation. DIFA Engineer performs the following actions:

- Uses **5-Whys method** (See Annex 7) or other methods of Root-Cause Analysis**.**
- Analyzes all the documents for the non-conformities / findings related to the Possible failure causes (see Annex 4).
- Determines Root-Cause: General
- Determines Root-Cause: Specific

10.3 Based on the determined Root-Cause, DIFA Engineer completes DIFA Report, determines Party in fault and future actions.

DIFA report shall be prepared within 5 working days after the teardown of the last unit of the failed ESP system.

DIFA Report should consist from the following parts:

1 Well History
2 Equipment List
3 Failure notification notes
4 Failure analysis:

4.1 Findings in Operation History (analysis of VSD Logs; daily well flow rate; well flow rate for the last 3 days before failure; daily dynamic fluid level; dynamic fluid level for the last 3 days before failure; annulus pressure; manifold pressure; basic sediment & water; causes of well shutdown for the entire period of operation of ESP; etc.)

4.2 Findings in Dismantling Notes

4.3 Findings during inspection (summary of Dismantle observations, pictures, failed items and failure descriptors)

NOTE	If the party at fault was preliminary determined as Novomet Factory, it is necessary to specify in the DIFA report the numbers of positions for the failed components as per the Drawing. You can find the corresponding nomenclature (Drawing No.) in the product certificate.

5 Conclusion (primary failed item, primary failed descriptor, root-cause of failure, party in fault)

6 Recommendations

7 Comments from the Customer

8 Attachments (Inspection reports, Dismantling Report and other documents required to provide evidence of the correct failure analysis).

10.4 DIFA Engineer approves DIFA Report internally.

NOTE	If the failure preliminary caused by NOVOMET Factory of by NLS Facility DIFA findings shall be sent to Head of KPI control group of HQ before DIFA report filled out.

10.5 DIFA Engineer submits the signed DIFA Report to the Customer and receives the Customer's approval.

If the Customer does not accept DIFA Report, DIFA Engineer discusses it with the participants of the Committee and Customers and makes corrections if necessary.

NOTE	Results of DIFA of the supervised equipment shall be provided to HQ: to International QA/QC Manager and Head of KPI control group.

10.6 If the failure related to Novomet Group of Company (ESP failure) without disturbances of operating conditions, the Location performs actions in accordance with the responsibility described in the corresponding section of this procedure.

10.7 DIFA Engineer determines if it is necessary to prepare NCR. In this case, prepare the NCR according to the procedure NLS-QHSE-P4.

NOTE	Pay attention that the NCR shall be prepared based on the DIFA Report, VSD Logs, dates received from the laboratory, pictures, etc.

10.8 DIFA Engineer determines if it is necessary to develop CAPA Plan related to the failure. In this case, DIFA Engineer informs International QA/QC Manager. International QA/QC Manager determines the necessity and person in charge of CAPA Plan preparation: Location or HQ. Follow the procedure NLS-QHSE-P5.

NOTE	If the responsibility for equipment failure is assigned to the Location, CAPA Plan shall be developed and sent to HQ: International QA/QC Manager and Head of KPI control group. CAPA Plan shall include the root cause of the failure, corrective actions (to prevent this problem in the future), people responsible, and deadlines. In the case of occurrence of the new facts or additional questions during CAPA Plan implementation, it could be added either from HQ or from the Location side. QA/QC Engineer Local updates and checks the implementation of the CAPA Plan.

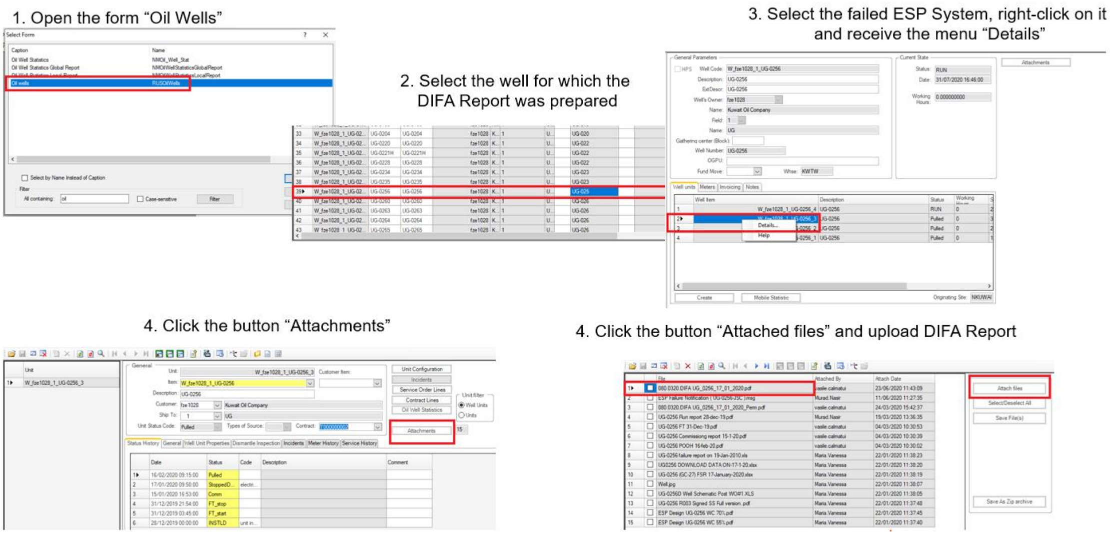
10.9 DIFA Engineer determines if it is necessary to prepare Quality Alert. In this case, DIFA Engineer informs QA/QC International. QA/QC International determines the necessity and person in charge of Quality Alert preparation: Location or HQ. Follow the Procedure NLS-QHSE-P5.

10.10 DIFA Engineer updates DIFA Register Table (NLS-QHSE-P72-F7).

10.11 DIFA Engineer uploads DIFA Report to the Corporate Portal.

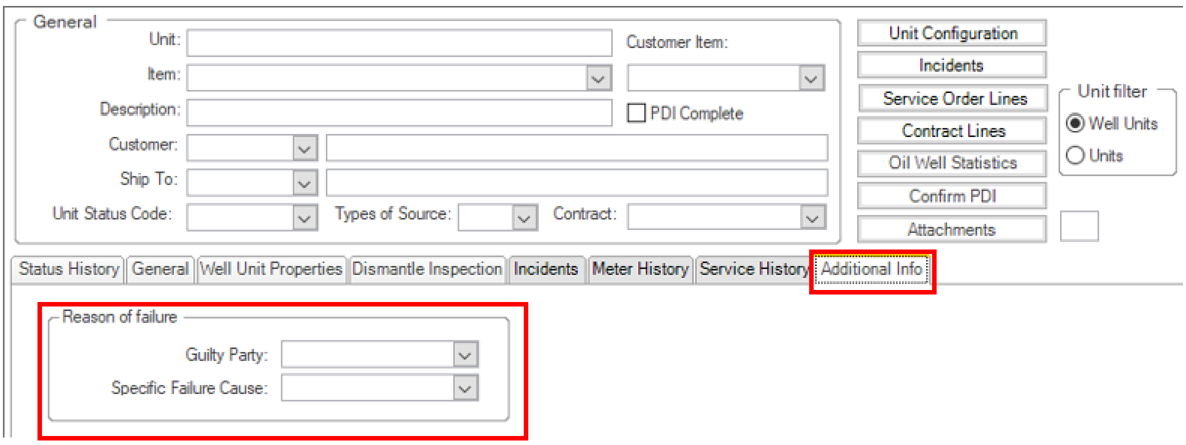
10.12 DIFA Engineer uploads DIFA Report and all the necessary documentation for the investigation to SyteLine 8.

NOTE



10.13 DIFA Engineer submits DIFA Results to FS Team and Application Engineer and selects the root cause of the failure and the guilty party in the form of “Unit” in SyteLine 8 in accordance with DIFA result.

NOTE



10.14 FS Representative Updates Weekly Report based on the received DIFA Results according to the Procedure NLS-QHSE-P30.

10.15 If the failure not related to Novomet Group of Company (Non-ESP failure), there are no Warranty Liabilities. Location performs future actions according to the Contract Requirements.

11. Annexes

Annex 1 – Possible reasons for Pull (ISO 15551-1)
Annex 2 – Possible failed items (ISO 15551-1)
Annex 3 – Possible failure descriptors (ISO 15551-1)
Annex 4 – Possible failure causes (ISO 15551-1)
Annex 5 – Electrical measurements
Annex 6 – Analysis of VSD Logs
Annex 7 – 5-Whys method

12. Forms

NLS-QHSE-P72-F1	Motor Teardown Report
NLS-QHSE-P72-F2	DHS Teardown Report
NLS-QHSE-P72-F3	Protector Teardown Report
NLS-QHSE-P72-F4	Pump Teardown Report
NLS-QHSE-P72-F5	Intake Device Teardown Report
NLS-QHSE-P72-F6	Cable Teardown Report
NLS-QHSE-P72-F7	Recommended DIFA Register Log
NLS-QHSE-P72-F8	CAPA Plan of DIFA's non-conformance

Document change notice

Revision	Description of change	Author	Date
1	First issue	Iuliia Michkova Artem Gusar	21.08.2020
2	Amendments 1. Correction of misprints (procedure and forms) 2. Adding note to p.10.3 • If the party at fault was preliminary determined as Novomet Factory, it is necessary to specify in the DIFA report the numbers of positions for the failed components as per the Drawing. You can find the corresponding nomenclature (Drawing No.) in the product certificate. 3. Adding to p.10.3 a requirement for the time of preparation of the DIFA report	Iuliia Michkova Artem Gusar	12.10.2021
3	Amendments	Iuliia Michkova	08.06.2022

	1. Adding note to p.9.11.22. Example of a damaged motor socket O-Ring 2. Adding a comment to the note in p.9.14.7. Wear of pump stages which indicates improper shimming during installation and/or improper ESP sizing 3. Adding note to p.10.12. How to upload DIFA report in SL8 4. Adding requirement to p.10.13. 5. Adding updated information to Annex 6. Analysis of VSD Logs	Artem Gusar	

Annex 1. Possible reasons for Pull (ISO 15551-1)

Reason for Pull: General	Reason for Pull: Specific	Description
Downhole Instrumentation Measured/Detected	High Motor Winding Temperature	Suspected failure indicated by abnormal downhole instrumentation measurements
	High Vibration	
	Abnormal Discharge Pressure	
Electrical	High current	Suspected failure indicated by abnormal electrical measurements or events (e.g. relay tripping, blown fuses, etc.)
	High voltage	
	Low current	
	Low Impedance/Resistance	
	Low Voltage	
	Phase Unbalance	
	Short Circuit	
	Current Leakage	
Flow	Low Flow to Surface	Suspected failure indicated by abnormal flow rate measurements
	No Flow to Surface	
Maintenance/Repair	Casing Repair	System pulled to conduct maintenance or repair on the well or on other downhole equipment.
	Tubing Repair	
	Sand Control Repair	
	Other Downhole Equipment Repair	
	Proactive ESP Replacement	
	Clean-Out	
Recompletion	Change Artificial Lift Method/Resize ESP System	System pulled to recomplete well.
	Converting Well	
	Change/Modify Producing Zone	
	Stimulation	
	Other	
Suspend	Permanent Abandonment	System pulled due to well being suspended.
	Temporary Abandonment	
	Shut In	
Other	Other	System pulled due to other reasons
	Economic	
	Logging well	
Pump stuck (ESP stuck)	High current	No the ESP rotation (accompanied by an excess of the operating current above the maximum allowed). If the insulation resistance is found to be reduced to 0 MOhm or there is no "Y-point balance", the well stop is classified as Low resistance.
	Overload	
Non-standard cases of failure (fall of downhole equipment)	Phase Unbalance	Fall downhole equipment involving the dismemberment of a tubing or ESP units during operation.
	Low Impedance/Resistance	

Annex 2. Possible failed items (ISO 15551-1)

System	ESP Unit	ESP Subcomponent		
ESP Assembly	Cable	Clamps / Fasteners Main Power Cable MLE	Packer Penetrator MLE Plug	Cable Splices Wellhead Penetrator
	Motor	Base Coupling Drain valve/Fill valve Filter Head Housing	Motor End connectors (Y-Point/Leads) Oil (Motor Fluid) O-Rings and other Seals Retaining Rings Rotor Bearing Rotors	Shaft Stator Thrust Bearing Varnish (Epoxy)
	Pump	Base/Intake Coupling Diffusers Head/Discharge Housing	Impellers O-Rings and Other Seals Retaining rings Screen Shaft	Shaft support Bearings Thrust Washers
	Intake device	Base Coupling Diffusers Discharge Ports/Screen Head Housing	Impellers Inducer Section Intake Ports/Screen O-Rings and Other Seals Radial Bearings Retaining Rings	Separation Section/Rotor Shaft Thrust washers
	Protector	Bag/Bladder/Bellows chamber Assembly Base Coupling Drain valve/Fill valve Head	Housing Labyrinth chamber Mechanical Seals Oil (Motor Fluid) O-Rings	Radial Bearings Relief Valves Shaft Thrust Bearing
	Other ESP System Component	Downhole Sensor Shroud		

Annex 3. Possible Failure Descriptors (ISO 15551-1)

Category	Failure Descriptors		Comments
Electrical	Failed Hipot Test	Open Circuit	Failures related to the supply and transmission of electrical power.
	High Impedance/Resistance	Short Circuit	
	Low Impedance/Resistance	Phase Unbalance	
External	Coated-External	Stuck Closed	Failures caused by external events or substances, e.g. paraffin, asphaltene, scale, sand, iron sulphide
	Coated-Internal	Stuck Open	
	Contaminated	Plugged	
Material	Brittle	Hardened	Usually related to the physical characteristics of the material, i.e. color, hardness, finish, etc.
	Burn	Melted	
	Corroded	Overheated	
	Discoloured	Swollen	
	Eroded/Pressure Washed	Worn	
Mechanical	Bent	Leaking	Usually the result of force, pressure or torque.
	Broken/Fractured	Loose/Spinning	
	Buckled	Low Efficiency	
	Burst/Rupted	Punctured	
	Collapsed	Scratched	
	Cracked	Squashed/Flattened	
	Damaged	Stuck	
	Dented	Torn	
	Disconnected	Twisted	
	Failed Pressure Test	Vibration/Rub Marks	
	Failed Vibration Tst	Vibration/Unbalanced	
	Faulty Clearance or Alignment		
Other	Maintenance Discard	Other	
	Missing		

Annex 4. Possible failure causes (ISO 15551-1)

Failure Cause: General	Failure Cause: Specific		Comments
System Design/Selection	• Equipment Selection • Equipment Selection - Materials • Improper Data Used in Design/Selection	• Equipment Selection - Pressure Capacity • Equipment Selection - Volumetric Capacity • System Configuration	• Improper system design/selection, including use of improper data errors in calculations • Inadequate pump flow or head capacity, motor power capacity, etc. • Improper equipment selection • Improper material selection
Manufacturing	• Equipment testing • Fabrication Problem	• Materials Selection • Quality Control • Mechanical Design	• Improper mechanical design of parts or components • Improper fabrication or assembly of parts or components • Improper equipment testing or quality control
Storage and Transportation	• Packaging or Restrains • Storage	• Transportation	• Improper or inadequate equipment handling during storage or transportation
Installation	• System assembly • Well Cleanout • Installation	• Installation - Service Rig • Reran Damaged Equipment	• Improper procedures during installation or well preparation • Improper system assembly, including cable splices and flange connections
Operation	• Enhanced Recovery Method or Production Strategy • Inadequate Monitoring	• Operating Procedure • Operation or Other Wells in Field • Well Treatment	• Improper operatinng procedures or inadequate monitoring • Field management practices
Reservoir or Fluids	• Asphaltene • Bottomhole Temperature • Free gas • Sand • Reservoir Failure • Low or No inflow	• Scale • Paraffin • Corrosive Fluids • Water Cut • High Inflow	• Unexpected reservoir conditions, leading to plugging by scale, paraffin asphaltene, sand, etc. or lower/higher productivity, higher GOR or water cut • Reservoir fracturing, subsidence, etc.
Completion	• Failure of Perforations/Liner/Openhole Failure or Improper Sand Control System	• Wellbore Completion Failure • Non-ESP Downhole Failure	• Failure of the wellbore completion (e.g. casing, tubing, packer, safety valve, liner)

Normal or Expected Wear and Tear	• Normal or Expected Wear and Tear		• Equipment run-life met or exceeded expectations
Technology Limitation	• Technology Limitation		• Current ESP technology unable to operate reliability in a given operation
Well Construction	• No Tangent Section		• The well was not designed/drilled for ESP application
Facilities	• Poor Power Quality	• Surface Equipment Failure	• Failure of Surface Instrumentation or Control
Other	• Natural Disaster • Power Disruption/Lightning	• Sabotage/Vandalism • Weather/Oceanographic	• Weather, war, terrorist attack, etc. • Failure of instrumentation control

Annex 5. Electrical measurements

System Motor+Cable / Motor check

To ensure personnel safety, perform the insulation resistance measurements for the system Motor+Cable when the cable is on a cable reel.

Treat cable ends by contact cleaner or other suitable agents to eliminate low resistance readings.

Insulation resistance measurements:

Ph-Ph test is performed to measure insulation resistance between phases and check the presence of Y-Connection.

1. Move apart the phases. Make sure that the cable conductors are not in contact with each other and not touching the armor.
2. Use megger from the set of Tools and accessories for ESP system servicing. Connect one megger lead to one conductor and the other lead connect to other conductor.
3. Check Insulation resistance by megger at voltage 2500 V. Record the received value.
4. Repeat p.2-3 for two other pairs of conductors.

Ph-Gnd test is performed to measure insulation resistance of motor/of the system motor+cable.

1. Move apart the phases. Make sure that the cable conductors are not in contact with each other and not touching the armor or cable reel.
2. Use megger from the set of Tools and accessories for ESP system servicing. Connect one megger lead to conductor and the other to cable armor/motor housing.
3. Check Insulation resistance by megger at voltage 2500 V. Record the received value.
4. Repeat p.2-3 for two other conductors: measure insulation resistance A-Gnd, B- Gnd, C- Gnd.

Always discharge each motor winding after measurements with a megger.
The megger discharges the equipment automatically when the test is over.

Residual high voltage could lead to electric shock and / or damage other measuring equipment.

Cable check

Treat cable ends by contact cleaner or other suitable agents to eliminate low resistance readings.

Insulation resistance measurements:

Ph-Ph test is performed to measure insulation resistance between phases of cable.

1. Move apart the phases. Make sure that the cable conductors are not in contact with each other and not touching the armor or cable reel.

2. Use megger from the set of Tools and accessories for ESP system servicing. Connect one megger lead to one conductor and the other lead connect to other conductor.
3. Check Insulation resistance by megger at voltage 2500 V. Record the received value.
4. Repeat p.2-3 for two other pairs of conductors.

Ph-Gnd test is performed to measure insulation resistance of cable.

1. Move apart the phases. Make sure that the cable conductors are not in contact with each other and not touching the armor or cable reel.
2. Use megger from the set of Tools and accessories for ESP system servicing. Connect one megger lead to conductor and the other to cable armor/motor housing.
3. Check Insulation resistance by megger at voltage 2500 V. Record the received value.
4. Repeat p.2-3 for two other conductors: measure insulation resistance A-Gnd, B- Gnd, C- Gnd.

Continuity test (Y-Connection).

Continuity test is performed to measure Ohmic Resistance of cable conductors. Ohmic Resistance shows a state of the cable conductors and phase balance. If there is big resistance of one of the phases, it means that there is phase failure.

1. Move apart the phases. Make sure that the cable conductors are not in contact with each other and not touching the armor or cable reel.
2. Use multimeter from the set of Tools and accessories for ESP system servicing. Attach one lead of the ohmmeter to one of the phase conductors. Attach the other lead of the ohmmeter to the other end of this phase.
3. Record the value of Ohmic Resistance to Dismantling Report.
4. Repeat p.2-3 for two other conductors.

Annex 6. Analysis of VSD Logs

1. Check the presence and version of the software for reading of VSD Logs. Upload the VSD Logs.
2. Check the validity of input data:
   - Well No./ Group of wells.
   - Motor parameters: rated values of hp, voltage, frequency, current, efficiency, power factor.
   - The validity of calculation of SUT tap.
   - The validity of VSD sizing based on the motor hp.
   - Sine-wave filter parameters: inductivity, capacity (in case of 0, check if it is the absence of sine-wave filter or data incorrectness).
   - VSD settings: motor type, motor acceleration/ deceleration time, switching frequency.
   - Drive settings (speed-up mode, synchronization frequency, synchronization time, frequency range).
   - Compare “Novomet Map of registers” with settings:
     - Motor protection: Underload - it shall be activated. The recommended value is minus 15% of the working load of the motor;
     - Motor protection: Overload - it shall be activated and set at 100% of the working load of the motor. It is allowed to increase this setting in accordance with table below:

For AM

Motor overload from nominal current, I_{oper}/I_{nom}	1.1	1.2	1.3	1.4	1.5
Allowed operating time, min	60	10	5	2	1

For PMM acceptable overload is up to 20% of the nominal value and not longer than 2 minutes of operation.

- U/F settings. These settings are set automatically when current motor voltage entering. But they can be adjusted by operator and it is important to check the correctness of this setting during VSD logs analyzing.

NOTE | U/F incorrect setpoints can lead to the surface or/and downhole equipment failure!

- DHS protection (if applicable) – high motor temperature. It shall be activated and set in accordance with the table below:

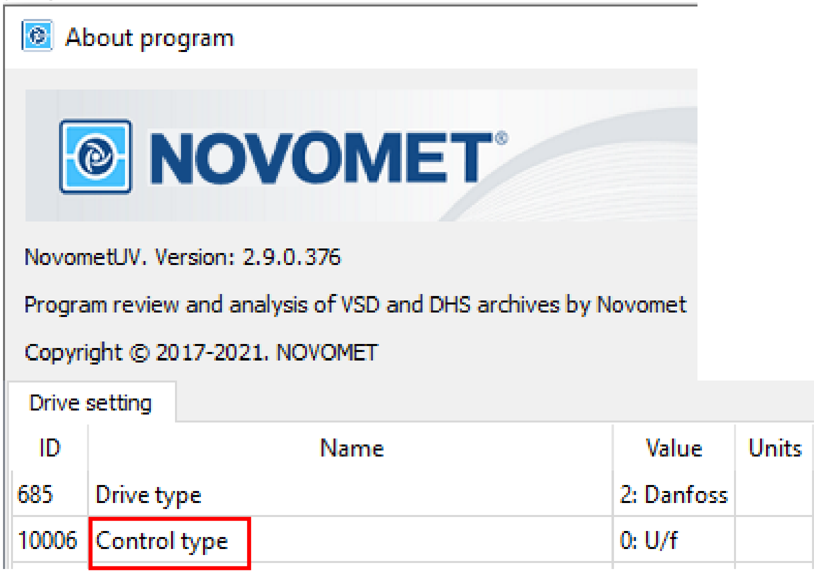
Maximum ambient temperature, ˚C	The value of the maximum long-term allowed temperature of the stator winding, ˚C	Exceeding the temperature of the stator winding, ˚C
90	170	80
120	170	50
150	200	50
170	200	30
200	250	50

- DHS protection (if applicable) – pressure intake. It shall be activated. Recommended value is not less than 20 Atm/2.03 MPa/294 psi/20.3 Bar.

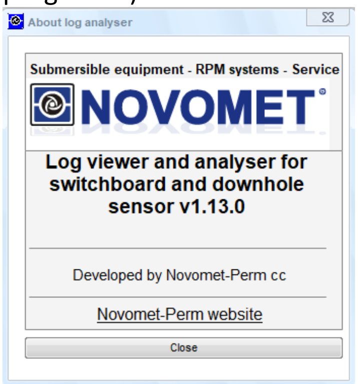
- "Control type": "U/F" or "Vector" (vector control is available for a permanent magnet motor);

NOTE

Example of the location of the Control type setting in NovometUV (new version of the programm)



Example of the location of the Control type setting in NovometUV (old version of the programm)



Novomet Universal Viewer

File | Service | Help

Data | Graphs | Settings | Crash logs | Archive of energ

Logs | Equipment | Protections | Modes | Options

Notes | Switchboard | Step-up transformer | Motor | VSD

№	Parameter	Value
33	Motor type	Permanent ...
41	Maximal operational voltage of ...	340 V
43	Rotation direction	Forward
44	Lower limit of motor speed	20 Hz
45	Maximal motor frequency	100 Hz
46	Fixed motor speed	50 Hz
47	Speed-up time	30 s
48	Slowdown time	30 s
49	PWM frequency	1,0 kHz
50	U/F characteristic U	13,000;74,...
56	U/F characteristic F	0,000;20,0...
60	Filter time of current regulator	0 ms
77	Type of control pad	U/f

Vector type control enables monitoring of PMM shaft torque. This ensures a higher start torque, more stable performance under a variable load, and increases VSD power efficiency through the best voltage supply to PMM.

Drive setting

ID	Name	Value	Units
685	Drive type	3: Etalon	
10006	Control type	1: Vectorial	

- DHS type.
- Version of the controller.

3. Check the process protections:
   - Exceeding / lowering of mains supply.
   - Phase unbalance.
   - Motor overload and underload, time delay, ACR (Automatic Circuit Reclose).
   - DHS.
4. VSD operation mode: constant/periodical with pauses.
5. Check the data: start date/failure date.
6. Set up the viewer:
   - Date.
   - Time.
   - Output frequency.
   - Motor data: current, voltage, power factor, load.
   - DHS data: insulation resistance, intake pressure, reservoir fluid temperature, motor winding temperature, vibration.

- Remove the rest excessive data.

7. Look for non-routine events: unplanned stops (protection operation), all the operator's actions, all the starts.

- VSD protection: Current limit (A59)
- VSD protection: Shutdown Udmin
- VSD protection: Overload (OverLD)
- VSD protection: Underload (UnderLD)
- VSD protection: Out of sync. during operation
- Etc.

Файл Сервис Справка
Данные Графики Уставки Аварийные архивы
События Текущие данные

	Date Time	Event
100	19.06.2021 14:58:20.113	Out of sync. during operation - activated 2->3
101	19.06.2021 14:58:29.750	Out of sync. at start - STOP 3->5
102	19.06.2021 14:58:29.750	DO2: VFD start-up locked 1->0
103	19.06.2021 14:58:31.777	Low intake pressure - activation delay 1->2
104	19.06.2021 14:58:31.777	High discharge pressure - activated 1->3
105	19.06.2021 14:58:31.001	Turnine rotation protection - activated 1->3
106	19.06.2021 14:58:31.777	Motor overheating - activation delay 1->2

ID	Date time	F, Hz	Ia, A	Ib, A	Ic, A	Imb.I, %
587143	2022-01-09 08:28:11	11.00	19.7	19.8	23.1	16
587144	2022-01-09 08:28:12	14.00	21.9	21.4	25.6	18
587145	2022-01-09 08:28:13	17.20	23.4	22.2	27.0	20
587146	2022-01-09 08:28:14	18.90	24.0	22.5	27.8	21
587147	2022-01-09 08:28:15	22.80	24.6	22.9	27.8	20
587149	2022-01-09 08:28:16	Protection activated: Motor Overload 105 > 100 %				
587150	2022-01-09 08:28:16	Lock on protection: Motor Overload				
587151	2022-01-09 08:28:16	Stop. Motor Overload				

ID	Date time	F, Hz	Ia, A	Ib, A	Ic, A	Imb.I, %
283261	2021-12-07 20:58:50	240.00	13.9	14.0	14.4	4
283262	2021-12-07 20:58:51	240.00	14.0	14.1	14.5	4
283263	2021-12-07 20:58:52	240.00	14.1	14.0	14.3	2
283264	2021-12-07 20:58:53	Protection activated: Motor Underload 53 < 55 %				
283265	2021-12-07 20:58:53	Stop. Motor Underload				

8. Analyze the found non-routine events. Compare the data of the non-routine events with the data of ESP normal operation.

In the case of ESP stop due to underload protection tripping, and if this protection is disabled subsequently, pay attention to the change in pressure readings at the intake / discharge of the ESP and the change in temperature readings at the intake of the ESP and the motor:

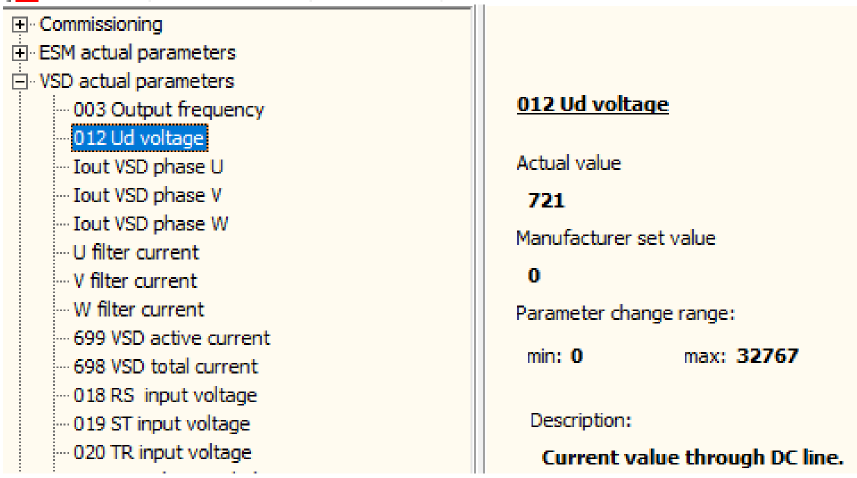
If the temperature and pressure at the intake rise, and the discharge pressure decreases before the underload protection tripping, this indicates a clogging of the intake screen of the pump and/or the pump itself. Also it could be an indicator of gas accumulation in the pump cavity or tubing leakage.

ID	Date time	F, Hz	Ia, A	Ib, A	Ic, A
[illegible]	[illegible]	Connection with DHS Restored			
538295	**2022-01-03 19:07:32**	Chg.Param. Overload Bypass delay 0:10			
538296	**2022-01-03 19:07:35**	Chg.Param. Overload Shutdown delay			
538298	**2022-01-03 19:07:44**	Chg.Param. Overload Restart -> Lock			
538302	**2022-01-03 19:08:13**	Chg.Param. Underload Restart -> Off			

VSD: Shutdown Udmin. The voltage in the high-voltage network affects the operation of the ESP. Low input voltage at the choke unit of VSD leads to an insufficient supply voltage for the motor stable operation. It leads to this protection tripping.

In the case of the protection tripping, check the values of input voltage and if there were any attempts to eliminate the defects during the setting of surface equipment.

N	Date	Time	Event
191772	11.02.2021	10:42:58	Shutdown Udmin
191773	11.02.2021	10:42:59	The reason is not ready: (Udmin)
191774	11.02.2021	10:43:00	Ready to start



VSD protection: Out of synchronization. This protection trips if the PMM Load torque exceeds the stator-rotor synchronism torque.

If this protection trips, check if there were any manipulations that ensure the correct restart of the ESP: settings of optimal currents – displacement angle (lag angle for rotor and stator) should be 240°, as the angle increases, the current decreases - as the angle increases, the current decreases.

ID	Date time	F, Hz	Ia, A	Ib, A	Ic, A	Imb.I, %	Motor U,	Id, A	U
24957	**2020-01-05 19:41:45**	Stop. Drive. Rassinchronization motor							
24960	**2020-01-05 19:41:46**	Backspin. Begin							
24961	**2020-01-05 19:41:47**	Backspin. End							
24973	**2020-01-05 19:42:56**	Chg.Param. Final displacement of calculation angle Id End 248 -> 240 °							

9. Analyze data curves:
   - VSD output frequency.
   - VSD input voltage.
   - VSD output voltage.
   - Motor current, motor load.

- Motor voltage.
- DHS data: intake / discharge pressure, motor winding temperature, vibration.

10. Determine the possible reasons of ESP failure based on the analysis of non-routine events and data curves. Predetermine the ESP units that should be subjected to a more detailed inspection.
11. Pay attention that the final reason of ESP failure could be detected after pull, dismantling, and inspection in the Workshop only.

Annex 7. 5-Whys Method

General information

The 5-Whys Method is an iterative questioning process used to explore cause-and-effect relationships of the problem.

The primary goal of the Method is to determine the root cause of a problem by repeating the question “Why?”. Each answer forms the basis of the next question. The method allows separating symptoms from the causes of the problem.

The final root cause (ultimate cause) may be achieved in less or more than 5 lines of questioning.

How to use the 5-Whys Method

1. Write down the specific problem.
2. Ask why the problem has happened and write down the answer.
3. If the answer doesn’t identify the root cause of the problem, ask why again.
4. Keep asking why until the ultimate root cause has been identified.

The Root-cause shall comply with the following requirements:

- The root cause is a fundamental breakdown/failure of the process
- If the root cause is corrected/eliminated, the failure will not repeat.
- If the identified root cause is applicable for other processes.