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Requirements

Classification: Internal

Status:  Relevant

Version: 4.0

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## TR3124 Uninterruptible Power Supply (UPS)

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Project development

Requirements, TR3124, Version 4.0,

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Document replaces version 3.02

### Relevant versions:

- [3.01](#) (2017-08-18 10:11)
- [3.02](#) (2019-06-05 14:17)
- [4.0](#) (2021-07-15 16:07)

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## 1 Objective, target group and provision

### 1.1 Objective

This document establishes the requirements for design, construction and testing of UPS systems for offshore/onshore units.

The UPS system (DC / AC) normally consists of rectifier, inverter, battery and main distribution board (DC UPS without inverter).

The requirements specified in this document should complement the governing regulations, national and international standards relevant for UPS system.

**SR-41459** - This document gives the supplementary requirements to IOGP S-701, S-702 and S-740 specification and datasheet [ST520](#) , [ST519](#) and [ST517](#). The IOGP QRSs are replaced by Ch.4 in this document.

The references listed in each clause are guides to standards with the requirements for the actual subject.

Requirements in other standards are not limited to these references.

The content in this document mainly specifies:

- Specific IEC requirements in more detail
- Which one out of several optional IEC alternatives to be used
- Requirements not covered in IEC
- Alternative requirements to the requirements described in IEC

### 1.2 Target group

The target group is personnel involved in selection, engineering, procurement and manufacturing of UPS systems.

### 1.3 Provision

Provision is made in Management System (TR3020 Electrical, technical requirements and standards).

## 2 General requirements for UPS types

### Single DC UPS system

A single DC UPS system is a complete system for transformation of AC supply voltage to DC voltage with a battery bank to obtain UPS in main power failure situations.

A single DC UPS system includes the following:

- Rectifier input isolating switch
- Isolating transformers for main incomer
- Rectifier
- Battery with battery racks
- Battery circuit breaker with trip facilities
- Main distribution board
- Incomer switch-disconnector for main distribution board
- Capacity discharge test facilities for batteries
- Black start facility from battery (when the main supply is not available)
- Insulation monitoring system
- Provisions for remote monitoring
- Mimic diagram on front

### Parallel DC UPS system

A parallel DC UPS system consists of two single DC systems working in parallel or as separate systems connected to a common or separate DC main distribution board.

Each of the two single systems forming the parallel system includes the same items as a single DC UPS system.

### Single AC UPS system

A single AC UPS system is a continuous duty, on-line, solid state system providing AC power to a main distribution board.

A single AC UPS system includes the following:

- Rectifier and bypass input isolating switch
- Isolating transformers for main incomer and bypass
- Rectifier
- Battery with battery racks
- Battery circuit breaker with trip facilities
- Inverter
- Static bypass switch
- Manual bypass switch
- Main distribution board
- Incomer circuit breaker for main distribution board
- Capacity discharge test facilities for batteries
- Black start facility from battery (when the main supply is not available)
- Insulation monitoring system
- Provisions for remote monitoring
- Mimic diagram on front

#### **SR-41477 - Parallel AC UPS system**

A parallel AC UPS system shall be two single AC systems, each connected to separate AC main distribution boards. If specified the two single systems shall be connected to a common AC main distribution board. The two AC main distribution boards shall have interconnection and synchronising facilities included to allow the two systems to operate in parallel. Each system shall be rated for 100% of the specified load.

## 3 Equipment requirements

### 3.1 General

**SR-41483** - The UPS unit shall have a static switch arrangement for automatic no break transition to bypass supply in case of inverter failure, short circuit, voltage out of tolerances on the 'Secure Bus' etc.

**SR-41485** - For parallel UPS systems, it shall be possible to remove one UPS unit for replacement without downtime on the distribution board.

**SR-41486** - For single AC UPS system, a switch facility between rectifier supply and bypass supply shall be provided. An interlock should be implemented to ensure that one incomer open before permission is given to close this switch. The switches shall be manually operated only, lockable and clearly marked.

### 3.2 Enclosures

Component IP should be according to TR3120 chapter 4.3.

There should be provision for cleating of incoming external cables according to TR3120 4.6.

### 3.3 Arrangement

**SR-41500** - All components in the panel fronts shall be flush mounted, and be mounted in the upper half of the front.

**SR-41502** - Bus bars shall be made of electrolytic copper.

Requirements for thermographic inspection on live equipment are provided in TR3120 chapter 3.9.

**SR-41505** - Output terminals in the UPS unit and input terminals in the main distribution board shall be equipped with duplicated terminals for future modification purposes.

### 3.4 Wiring

Internal wiring should be according to TR3120 chapter 4.10 and wiring identification according to TR3120 chapter 4.11.

**SR-41508** - All installation of primary wiring to equipment such as fuses, circuit breakers and measuring devices in connection with main circuits shall be made short circuit proof.

**SR-41509** - All internal cables between shipment sections shall be premade, marked, terminated and coiled in one of the sections.

### 3.5 Terminals

Terminals and terminal blocks should be according to TR3120 chapter 4.6.

### 3.6 Circuit breakers, Relays and Contactors DB

See TR3121 chapter 4.5. Circuit breakers should be equipped with alarm contact.

### 3.7 Earthing

Protective earth bar (PE) and Instrument earth bar (IE) should be installed according to TR3120 chapter 4.8.

### 3.8 Harmonic and ripple limitations

With reference to harmonic distortion requirements in IEC 61000-2-4 clause 6, class 1 requirement apply for the UPS system. See also IEC 61892-2, clause 10.7 and IEC 61892-1, clause 4.5.2.3.

**SR-41525** - The harmonic current feedback into the supply network shall, in normal operation, be limited to a crest factor ( $I_{peak}/I_{rms}$ ) of 2 unless otherwise stated in data sheet.

**SR-41526** - The UPS system shall withstand a minimum load crest factor of 3:1 ( $I_{peak}/I_{rms}$ ).

### 3.9 Electromagnetic compatibility (EMC)

References:

IEC 61000-2-4

IEC 61892-2

IEC 62040-2

### 3.10 Rectifier

**SR-41538** - The rectifier shall be capable of supplying the DC load with the battery disconnected, within the operational limits, and with due consideration to ripples, harmonics, over voltage etc. as specified in the data sheet.

**SR-41544** - Functionality shall be provided to keep the load voltage within +/- 10% of the nominal voltage during all charging conditions on DC systems. Different load voltage limits may be necessary for particular applications.

**SR-41546** - The following local alarms shall be provided as a minimum, and be displayed on the front of the panels:

- Rectifier failure
- Rectifier fuse failure
- DC-over voltage (Pre-warning (H), Rectifier shutdown (HH))
- DC-under voltage
- Over temperature, (Pre-warning (H), Rectifier shutdown (HH))
- Main supply failure
- Battery breaker/fuse failure
- Earth fault

**SR-41547** - The following local status signals shall be provided as a minimum, and be displayed on the front of the panels:

- Main supply "ON"
- Battery switch "ON"
- Battery on normal charge
- Battery on boost/quick charge

**SR-41548** - For DC UPS systems in parallel mode the following apply:

- If the UPS system has two parallel rectifiers, the normal operation shall be that both rectifiers are working in parallel supplying the DC load and in addition float charging the battery. If one rectifier fails then the remaining rectifier shall be rated to supply the total DC load and its own battery float charge requirements.
- Parallel rectifier units shall be designed so that during parallel operation, load sharing shall occur. The difference between the rectifiers DC current shall not exceed 10 % of the rated current for one rectifier.

### 3.11 Battery, racks, circuit breaker

References:

DNV GL RU Ship Pt.6 Ch. 2, Section 2

IEC 62485-2

IEC 60623

IEC 60896-11

IEC 60896-21

IEC 60896-22

IEC 61892-3 clause 9

IEC 61892-6 clause 9

IEC 61892-7 clause 26

IEC 62619

Important factors to consider regarding battery design are capacity, lifetime, load profile, temperature, charging condition, available space and weight capacity. The calculated discharge time should decide if the battery should be of the normal type, the high energy type or the high power type.

#### 3.11.1 Batteries

**SR-95082** - The battery cells shall be Nickel Cadmium, Lead-Acid, or Li-ion type and the requirements in IOGP S-740 shall also apply for Li-ion type battery. The battery type should be selected to minimize space, weight and maintenance.

Reference is made to TR3120 Chapter 3.1 with regards to degree of protection.

**SR-41563** - Emergency batteries shall have a capacity to supply emergency power for a period of minimum 30 minutes, ref. ISO 13702, table C1. UPS for emergency lighting shall have a capacity of 60 minutes, ref. EN1838 section 4.2.5. These batteries shall be dimensioned to

supply rated load for 30 or 60 minutes (according to requirement above) when charged to 90% of rated capacity at an ambient temperature of 5°C throughout the specified lifetime.

An alarm indicating rectifier fault may be implemented instead of discharged battery alarm.

References are made to 3.11 in this document.

**SR-41567** - Transparent containers are not applicable for other batteries than those requiring refilling of electrolyte. Lead-Acid battery shall be provided with Ex-plugs to secure easy and safe check of electrolyte weight.

Individual cell voltages in a battery should not deviate by more than 15 mV when delivered from manufacturer (new).

**SR-41570** - The torque values on battery poles shall be specified and clearly marked on each battery cell or battery bank rating plate.

### 3.11.2 Battery racks

Best practice for selection of the battery rack type in order to minimize maintenance scope and complexity should consider the following:

- All cells or modules to be easily lifted out
- All cells or modules to be easily available for measurements (electrolyte weight, voltage etc.)
- Electrolyte level to be visible without moving any cell (For relevant batteries)
- Minimum of floor space and weight

### 3.11.3 Battery circuit breaker

If 24 V DC internal control voltage is available in the UPS unit, this voltage is recommended used for battery breaker trip coil (UVT). However, this is based on that the control voltage extinguishes short time after the UPS shut down and that the voltage is restored before closing the battery breaker (e.g. by charging the UPS DC circuit by use of UPS rectifier or charging the DC circuit from battery via push button and resistor in parallel with battery circuit breaker).

**SR-41580** - The tripping of the battery breaker shall be controlled by an adjustable time relay located in the UPS or in an external battery breaker.

The time relay shall have the following three inputs:

- Start timer

- Reset timer
- Immediate trip

The time relay shall have a lockable manual override switch. A local alarm shall be provided to show status of this manual override switch.

**SR-97865** - If the battery circuit breaker is part of a safety instrumented function the delivery shall be:

- compliant with IEC 61508 or proven in use/prior use in accordance with IEC 61508/IEC 61511
- and in accordance with the SIL requirement of the Safety instrumented function as specified in the data sheet and the Safety Requirement Specification

Note: the Safety Requirement Specification (SRS) is a document provided by the purchaser (ref. IEC 61511-1 10.3)

### 3.12 Inverter

**SR-41590** - The inverter shall be designed to supply a load consisting of 100 % switched-mode power supplies.

**SR-41593** - The inverter shall meet the dynamic voltage/ frequency requirements in table 1 regarding connection/disconnection of load.

**Table 1 – Dynamic voltage/ frequency requirements**

| Loads               | Within ¼ period | Within 10 ms | Within 100 ms    |
|---------------------|-----------------|--------------|------------------|
| 0-50 % load on/off  | Max ± 30 %      | Max ± 10 %   | Project specific |
| 0-100 % load on/off | Max ± 50 %      | Max ± 30 %   | Project specific |

### 3.13 Bypass Transformer

The transformer short circuit impedance should be chosen with regards to voltage drop in the transformer and the short circuit level on the UPS main distribution board.

### 3.14 Static transfer switch

**SR-41605** - In case of inverter failure, the static transfer switch shall transfer the load from the inverter to the bypass circuit. The monitoring circuits shall be designed to minimise spurious operations due to load changes and other transient conditions.

**SR-41606** - If the UPS switches over to the bypass supply due to inverter failure, the logic shall lock out the inverter and shall not automatically transfer back to the inverter supply. No-break return to the inverter supply shall be manually initiated.

**SR-41607** - In case of a short circuit on the outgoing feeders, the UPS shall automatically switch to bypass mode if bypass is available. When the short circuit is cleared, the UPS shall automatically switch back to inverter mode.

### 3.15 Main distribution board

If a separate main distribution board are provided, the requirements to distribution board is found in TR3121.

**SR-41611** - Selection of miniature circuit breaker (MCB) / fuses shall be based on a protection and discrimination study.

**SR-41612** - All live parts shall be protected against accidental touch.

**SR-41613** - Each main distribution board with IT system earthing shall be equipped with an insulation monitoring system and a common alarm:

- The insulation monitoring system shall automatically identify earth fault individually on all feeders to sub-distribution boards.
- Each outgoing feeder from the main distribution board shall be protected by a MCB/MCCB (or fuse) with an additional alarm contact.

**SR-41614** - The following local alarms shall be provided as a minimum:

- MCB/MCCB/Fuse tripped
- Earth leakage

### 3.16 Control, metering and protective devices

**SR-41617** - The UPS unit shall have a mimic diagram on the front showing operational modes and voltage/ current/ frequency. The diagram shall show the system status and incorporate symbols, operating switches and indicating lights. The major components such as bypass switches, isolating switches and circuit breakers shall be shown with indicating lights.

**SR-41620** - Each UPS unit shall have a separate control unit operating 100% independently of other UPS units, i.e. a parallel UPS system shall have two control units. Each control unit shall have separate settings for all relevant parameters.

**SR-41621** - The UPS unit shall be equipped with insulation monitoring device. Battery earth leakage monitoring shall be included.

Protection should be in accordance with TR3120 chapter 4.4.7.

### 3.17 Protection and discrimination study

References:

IEC 61892-2, Clause 10.5

**SR-41626** - Discrimination between UPS / bypass / battery breakers and fuses in the main UPS distribution board shall be documented. Selection and coordination of protection devices shall ensure selectivity in all modes of operations.

**SR-41627** - Maximum rating of fuses from main distribution board to achieve protection discrimination without shutdown of the UPS shall be stated.

## 4 Inspection and testing

### 4.1 Inspection

**SR-41630** - The equipment covered by this document shall be subject to inspection during fabrication, construction and testing.

### 4.2 Type Test

**SR-41632** - Type test shall be performed according to IEC 62040-3 clause 6.1.5. Test certificates for tests which have been carried out on similar equipment, shall be provided on request.

### 4.3 Shop Test

**SR-41634** - A test procedure shall be provided based on the following requirements.

**SR-41635** - The results of all tests shall be recorded on test sheets together with all rated values and equipment data.

**SR-41636** - Applicable shop tests shall be carried out on the completed equipment in accordance with the relevant standards and recommendations. Shop tests shall be fulfilled before factory acceptance tests.

These tests should include:

- Checking of data
- Mechanical inspection
- Insulation test
- High voltage test
- Complete operation and functional test
- Primary injection tests on protective relays
- Check of relay settings
- Frequency shift test
- Check of all alarm functions
- Perform manual return to inverter output from bypass supply, and record results on oscillograms
- Simulating of inverter failure which would cause transfer of load from inverted output to bypass supply, and recording of results on oscillograms.
- Short Circuit Test. Simulated test for the correct functioning of the distribution protective device should be made through an impedance which represents the load loop, in addition

to a direct short circuit. The output shall be recorded on an oscillogram

#### 4.4 Factory Acceptance Test (FAT)

**SR-41639** - The UPS system shall for each project be subject to the standard test listed in table 2. The UPS with distribution board shall be tested with a suitable battery bank.

**SR-41640** - These tests shall be considered to be the minimum test requirements for an UPS system. If additional tests are required, then they shall be specified in the UPS data sheet.

**Table 2 – Uninterruptible power supply (UPS) system test requirements**

| Item no | Standard test                                                                                                                                                                                                                                                                                                       |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | Visual inspection and check of wiring and dimensions according to project drawings.                                                                                                                                                                                                                                 |
| 2       | Insulation test.                                                                                                                                                                                                                                                                                                    |
| 3       | A complete functional test.<br>This test shall also include test of supervisory and remote signalling circuits.                                                                                                                                                                                                     |
| 4       | Full load test.                                                                                                                                                                                                                                                                                                     |
| 5       | Short circuit test in inverter mode                                                                                                                                                                                                                                                                                 |
| 6       | Short circuit protection device test.<br>Test shall be performed to document the selectivity in the UPS distribution.<br>Identical type of largest fuse and/or circuit breaker as installed in the UPS main distribution board shall be included in the test. Test shall be done with and without bypass available. |
| 7       | Earth fault test.                                                                                                                                                                                                                                                                                                   |
| 8       | Transfer test.<br>Measurement of UPS output voltage quality. The test shall document proper function of the UPS voltage regulation during switching between all different modes of operation.                                                                                                                       |
| 9       | Battery discharge test function shall be demonstrated.                                                                                                                                                                                                                                                              |
| 10      | Restart test.<br>Black-start of UPS system shall be demonstrated.                                                                                                                                                                                                                                                   |
| 11      | If battery is Li-ion type, it shall be possible to test / verify the internal diagnostics and protective functions of the BMS instrumentation prior installation and during commissioning and as part of later maintenance                                                                                          |

## 5 Labelling

Reference is made to TR3120 regarding labelling.

## 6 Additional information

### 6.1 Definitions and abbreviations

|                         |                                                                                                                                                                                                                                                                                                                |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Shall (requirement)     | Requirement strictly to be followed in order to confirm to the document and from which no deviation is permitted, unless a deviation permit is approved.                                                                                                                                                       |
| Should (recommendation) | Indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required, or that (in the negative form) possibility or course of action is deprecated but not prohibited. |
| May                     | Indicates a course of action permissible within the limits of the document.                                                                                                                                                                                                                                    |
| Can                     | Statements of possibility and capability, whether material, physical or causal.                                                                                                                                                                                                                                |

|      |                               |
|------|-------------------------------|
| AC   | Alternating Current           |
| DC   | Direct Current                |
| EMC  | Electromagnetic Compatibility |
| IP   | International Protection      |
| IT   | Insulated Terra               |
| LCI  | Life Cycle Information        |
| MCB  | Miniature Circuit Breaker     |
| MCCB | Moulded Case Circuit Breaker  |
| RMS  | Root Mean Square              |
| UPS  | Uninterruptible Power Supply  |

## 6.2 Changes from previous version

Changes in version 4:

Prepared for use of IOGP specification S-701, S-702 and S-740, with supplementary requirements.

Section 3.12,1: Preparation to allow Li-ion battery technology.

Update of references in the whole document.

### Changes in version 3.02:

Document updated from Statoil template to template. Wording "Statoil" changed to """. Insignificant changes, performed by system administrator, on behalf of author/owner.

### Changes in version 3.01:

Published in new minor version as part of the GEM-project (Governing Element Management). TR-document is digitalized, and each requirement element is now identified with a unique ID

### Changes in version 3:

There are editorial updates and clarifications in all sections.

The main changes are as follows:

- Generally, TR3120 is referred to for general requirement for electrical equipment.
- Section3.1: Requirement regarding air-cooling is modified.
- Section3.1: Requirement regarding switch facilities for AC UPS is modified.
- Section3.8: : Requirement regarding noise limit is modified
- Section 3.12.1: Requirement regarding calculating battery capacity is modified
- Section 3.13: Requirement regarding UPS withstand of overload is modified
- Section 3.13: Requirement regarding short circuit capability will be stated via datasheet.
- Section 4.2: Added reference to type test
- Section 4.4: Table 2, item 5. Short circuit test shall be in inverter mode
- Section 4.4: Table 2. Requirement for audible noise test is deleted.

### 6.3 References

**SR-41652** - The following standards include provisions and guidelines which, through reference in this text, constitute provisions and guidelines of this document. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used as long as they fulfil or exceed the requirements and guidelines of the standards referenced below.

Note that references in this document are based on year of issue as listed below.

|                              |                                                                                                                                                                                      |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DNV GL RU Ship Pt.6<br>Ch. 2 | Rules for classification, Part 6 Additional class notations, Chapter 2 Propulsion, power generation and auxiliary systems                                                            |
| IEC 60623, 2001              | Secondary cells and batteries containing alkaline or other non-acid electrolytes-<br>Vented nickel-cadmium prismatic rechargeable single cells                                       |
| IEC 60896-11, 2002           | Stationary lead-acid batteries, Part 11: Vented types General requirements and methods of tests                                                                                      |
| IEC 60896-21, 2004           | Stationary lead-acid batteries, Part 21: Valve regulated types Methods of test                                                                                                       |
| IEC 60896-22, 2004           | Stationary lead-acid batteries, Part 22: Valve regulated types Requirements                                                                                                          |
| IEC 61000-2-4, 2002          | Electromagnetic capability (EMC)- Capability in levels in industrial plants for low-frequency conducted disturbances                                                                 |
| IEC 61892-1, 2019            | Mobile and fixed offshore units-Electrical installations - Part 1: General                                                                                                           |
| IEC 61892-2, 2019            | Mobile and fixed offshore units-Electrical installations - Part 2: System design                                                                                                     |
| IEC 61892-3, 2019            | Mobile and fixed offshore units-Electrical installations - Part 3: Equipment                                                                                                         |
| IEC 61892-6, 2019            | Mobile and fixed offshore units-Electrical installations - Part 6: Installation                                                                                                      |
| IEC 61892-7, 2019            | Mobile and fixed offshore units-Electrical installations - Part 7: Hazardous Areas                                                                                                   |
| IEC 62040-2, 2018            | Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements                                                                                       |
| IEC 62040-3, 2021            | Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements                                                                             |
| IEC 62619, 2017              | Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications |
|                              |                                                                                                                                                                                      |

|                 |                                                                                                                                                         |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| ISO 13702, 2015 | Petroleum and natural gas industries —Control and mitigation of fires and explosions on offshore production installations — Requirements and guidelines |
| TR3120          | Electrical equipment, general requirement                                                                                                               |
| TR3121          | Switchgear and distribution boards                                                                                                                      |