RECOMMENDED GUIDELINES FOR
DEPLOYMENT OF RFID
ON
THE NORWEGIAN CONTINENTAL SHELF

- Mobile equipment -

THE NORWEGIAN OIL INDUSTRY ASSOCIATION (OLF)
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1 Introduction
This guideline for deployment of Radio Frequency Identification (RFID) on the Norwegian Continental Shelf (NCS) addresses the main needs and requirements of the offshore industry for operational information in the area of locating and tracking mobile equipment.

2 Domain

2.1 Mobile equipment
The mobile equipment is defined as the equipment that is not connected to a fixed, tagged location on site (onshore + offshore). Mobile equipment may be moved on a site or between platforms or other locations. The equipment may be hired from a vendor or belong to the operating company itself. Examples of items that may be classified and handled according to the “mobile equipment” procedures are: Tools - air tools, welding machines, drills etc., Equipments - scaffolds, lifts, trucks, container etc., and Materials - flanges, spools, pipes (that are not covered by the drill string area) etc.

A key challenge for mobile equipment is that very different solutions are required depending on whether the main business driver is the automatic identification of an asset/equipment (and whether this is at close range or from a distance e.g. passing through a portal or gateway) or whether the business need is to track the location/position of a mobile asset/equipment.

RFID systems in the deployment area of mobile equipment are used to identify and locate tools efficiently to avoid delays in production or, even total work stoppages. The general requirements for the RFID systems used in mobile tracking are:

- Unambiguously identify the equipment
- Locate a particular equipment when is required
- Track the movement of the equipment within a platform offshore or on a base onshore and at entry and exit points
- Automatically transmit the movements of the mobile equipment to the enterprise system and to a repository for record
- Record the mobile equipment has been issued to or is in the custody of a particular operator/company employee

The requirements presented in these guideline will be applied to different implementation solutions and different approaches to fulfilling these requirements are considered. The guidelines consider that there will be different right solutions and implementations to fulfil the requirements.

3 Business objectives
There are several motivations for RFID tagging of mobile equipment. RFID data capture technology enables the automated localization and tracking of mobile equipment and provides a documented history for each equipment and helps ensure that the right equipments are shipped to the right customer, while documenting and validating the movement. A consequence of this is faster access to equipment when needed. This will also give a better utilization of the available equipment and hence the total number of equipment required is reduced. Another advantage is better logging of equipment performance and maintenance. RFID tags can be embedded or attached to mobile equipment in order to check for exceptions to steady state in supply chain, system monitoring, reaction to environmental change etc. This will ensure faster order of spare parts; repair and shorter time before equipment can be put back in operation. The functionality
and quality can be logged as a basis for decisions on hiring or buying new equipment. RFID tagging ensures faster and more correct identification of items than what can be achieved through manual visual inspection. This is also a security issue since correct identification is important to ensure that the right equipment is used for the right purpose. Automatic tracking of equipment will also reduce the probability that items are lost/forgotten or stolen.

![Fig. 1: Information flow.](image)

RFID tagging is considered a low cost investment compared to the expected savings. The chosen RFID technology has to be adapted to the conditions and environment but will have little influence itself on the environment and how other unrelated work procedures are done. Optimal utilization of the technology may result in new or changed routines like control and check of equipment id-numbers on a regular basis or when entering or leaving locations. However, if this is already done manually RFID check will be faster and more accurate.

Tracking and tracing of mobile equipment as defined above should take place all the way throughout the supply chain from supplier, onshore warehouse, supply ships (transporters), offshore, supply ships (transporters) and return to onshore warehouse / back to supplier, in order to:

- Increase productivity and utilization of human resources
- Faster (immediate) and more correct registration
- Faster access to present and historical maintenance data
- Improved efficiently through better tracking and localization of available resources
- Reduce manual processes & activities
- Reduce costs throughout the supply chain
- Improve reverse logistics
- Reduce freight and logistics costs
- Improve efficiency within warehouse management
- Increase efficiency across the supply chain
- Improved performance through better logging of the quality of different equipment models
- Increased safety through more correct identification of items
3.1 Safety
Using RFID will increase the overall safety since the equipment will be identified faster and more accurate. It will be easier to identify equipment with an unhealthy history. It will also be easier to identify the correct user manuals.

The most critical is that the correct ID is read for each item and that the correct data entry is picked up from the databases. Hence it is important that not two items can have the same ID. It is also important that tag and/or reader interprets the ID as something else than what it should have been.

Application scenarios that can be used when the equipments are tagged are to check whether safe storage limits have been exceeded (e.g. storing inflammable items is only allowed for a limited number of items), non qualified use of equipment, only enable equipment if use can “prove” appropriate qualification, inadequate/missing safety equipment, check whether required safety equipment and other requirements are present.

3.2 Quality
Obviously it is important that a high percent of the tags are actually working. Hence each tag has to be designed to resist the rough environment it will be exposed to. However we can not ensure that the tags will manage this without failure for all cases and redundancy solutions are required. If possible all tags should contain the ID in a human readable format.

In may also be an option to achieve redundancy by putting RFID tags several places one each items. However this raises the question whether the different tags should have the same ID-number or not. If they have the same number there will be an increased risk that different items by accident got the same number. If each item gets several different ID-numbers there are a risk that we get confusion in the databases. Both cases should be rare but there an increased risk that they may occur.

Multi frequency tags will make it easier to read tags since some frequencies reach longer distances while others work better when covered by ice, in the neighbourhood of metal structures etc.

In addition to the technical performance it is important that operator routines are developed and followed. It is important that the equipment is actually registered when entering or leaving a location. Hence it is important the transport of equipment is done in such a way that registration is likely to occur.

In the case of mobile equipment several companies (supplier, vendor, operator and protractor) will have to access and put data into the same data system. Hence it is important that the system is user friendly, cooperate with the systems at the different companies and is protected for intended or non-intended incorrect or harmful operations.

3.3 Efficiency
RFID registration is faster and more accurate than human registration. Having more data on electronic format will also make it easier to access and maintain the history of the equipment. It is also easier to identify what equipment that is in use and to identify available equipment when needed.
4 Cost and benefits
There are several tangible benefits related to each of the above business objectives. These are however, related to the specific application throughout the value chain. Some benefits are listed below:

- Generation and maintenance of lifetime information
- Reduced labour
- Faster, simpler and more accurate registration
- Better data quality
- Better tracking and localization of equipment
- Increased control of tools and equipment
- Improved material handling
- Improved equipment utilization
- Reduced stock of equipment
- Standardized registration and databases
- Faster identification resulting in faster access to correct manuals etc
- Better HSE

5 Antenna, tags and sensors
RFID tags are classified as passive, active or semi-passive. Passive tags receive all energy required from the RFID reader while active tags have an alternative energy source. The most common active energy source is batteries while also super capacitors and energy harvesting is possible. The semi-passive tags receive energy from the RFID reader but are equipped as well with a battery for data processing.

5.1 Frequency
Different frequencies have different capabilities and limitations. To achieve efficient antenna matching the tag antenna should have a size similar to the transmission wave length (or to \(\frac{1}{4}\) to be accurate). Hence, lower frequencies with wavelengths significantly larger than the size of the tag antenna results in reduced energy transfer. However on the other hand longer transmission wave lengths are less influenced by obstacles. Hence, different frequencies may be preferred under different conditions. The possible frequencies for passive/active RFID-tags can be in the LF, HF, UHF or SHF frequency band.

When it is possible that the RFID tag may be covered by water, ice or pollution and it may be situated close to water or large metal structures, low frequency (LF) magnetic field communication may be preferred. A possible protocol in this case is the RuBee protocol (meeting the IEEE P1902.1 standard).

5.2 EX/ATEX
Ignition protection in explosive atmosphere is required. There is an absolute demand for EX/ATEX certificate for both tags and offshore readers. The following requirements are applicable for tags: Hazardous Zone 0/1, Gas group IIC and temperature class T4/T6. This can be solved by mounting the equipment in cabinets that has the needed EX certification and have everything certified as a whole unit. In general it is easier to satisfy the EX/ATEX requirements with passive than with active tags. Hence passive tags are recommended.

5.3 Environment
While there may be different environment requirements from mobile unit to mobile unit we specify the same requirements for the tag unit. The specifications for the RFID tags is sat to the
worst environments that any mobile device is intended to experience. The tags for mobile equipment should work under the following conditions:

- Operating temperatures varying from -40 °C to +85°C
- Washing temperature up to 100°C may be relevant.
- Relative humidity up to 100% RH without condensing for a long time
- The material used to make the RFID tags should be water proof and may be sound hygienic. All used material both external and internal shall be corrosion and fire resistant, low smoke and halogen free
- Wind speeds at 35m/s with gusts up to 45m/s
- Shocks up to 50g, (DIN IEC 68-2-27) and multiple drops to concrete from 1.5m
- Vibration up to 3g, 20 sine wave cycles, 5Hz to 150Hz, (DIN IEC 68-2-6/ 5g), noise 5Hz to 1000Hz, 30min, (DIN IEC 68-2-64)
- Electromagnetic compatibility (EMC): The EMC directive 2005/108/EC (EU)
- Salt
- Wet
- Metal
- Interference
- Strong jets of water
- Ice
- Aggressive gases and liquids
- Physical strain (sharp hits, heavy impact, long time wear and tear)

5.4 ID numbering
ID numbering should be based on the industry numbering standard and according to the same, common standard as for all equipment on the Norwegian Continental Shelf. The numbers should be unique for each item. Each ID issuing authority will have a unique company number as part of the ID numbers. A common database is not necessary and companies and partners may have access to information of only parts of the numbered items. However it is important that two items, say from different suppliers, do not have the same ID-number.

5.5 Semantics

5.6 Security
Security issues:
- Choosing passive tags makes it easier to satisfy the EX/ATEX requirements
- Data redundancy reduces the possibility that an ID should be misinterpreted as another number
- Backup representation of the ID (say as a written number on the tag) increases the security if the RFID is not working

6 Antenna and readers
The main purpose of the reader is to get the ID number of the RFID tag. If the tag contains sensors, the reader must be able to read the sensor data. The reader may operate off-line trusting local storage or on-line through a cable or wireless connection to a data base.

Off-line operation:
In the case of off-line operation the reader has to store the read ID number and possible sensor data for later uploading to the database. It may also have to store information manually entered
by the operator. The data is uploaded to the database at the end of each work shift (or more frequent if needed).

If the operator needs additional information about the items while working on them, this data has to be downloaded in advance. Such information may be historical measurement or calibration data for each individual item. Another possibility is to download user and maintenance manuals. This requires an advanced knowledge of which items that will be read. If an unexpected item is found the operator has to return to the docking facility to download the proper data/manuals.

**On-line operation:**
On-line connected readers offer instant uploading of IDs and new maintenance data and downloading of historical data and user manuals for all items found in the database. Instant uploading of maintenance data will allow that ordering of spare parts and replace equipment can be done at once. It will also ensure that no data is lost if the reader should stop working/be lost etc. An on-line reader requires less memory and processing capacity than an off-line counterpart. On-line readers may be wireless or cable connected. Mobile on-line readers will normally be wireless while fixed on-line readers may be either.

**Types of readers:**
Possible readers are:
- Mobile readers like PC’s/PDA’s
- Ports (i.e. fixed reader structures at strategic positions that the objects have to pass through or close by)
- Readers in crane hooks, lifts, forklift etc

The mobile readers will normally be carried by personnel. The simpler versions (PDA’s) should survive rough conditions and to be stored outside for a longer time. More advanced mobile readers (PC’s) should minimum withstand the conditions that the users have to manage.

The equipment that is necessary to set up a portal can be mounted in or connected to a cabinet. Depending on the requirements from the operator the portals can be set up with one cabinet containing:
- Hub (for processing and storing of data)
- Reader
- Switch
- Media converter
- Heater plate
- Power supply
- UPS power/Battery backup power
- Some kind of input (keyboard) or a keyboard interface
- Gas detector or other types of detectors

**6.1 Frequency**
The environments and conditions for the tags are probably tougher than the requirements for the readers hence they have to decide the frequency. Hence the choice of frequency should be defined by the standard(s) chosen for the Tags.

If the reader is on-line connected through a wireless connection, the wireless frequency is probably 2.4GHz. This is also one of the frequencies used for RFID reading. Although both connections are operating on the same frequency it is not believed that this will make any problems.
6.2 **EX/ATEX**
Ignition protection in explosive atmosphere is required, ref chapter 5.2.

6.3 **Environment**
Although it is simpler to protect the readers than the tags in general the off-shore readers should be able to operate under the same conditions as the tags.

6.4 **Security**
- Correct reading, storing and uploading of data
- Correct reading of data
- Able to read tag data
- Protection/firewalls to protect RFID data from other company databases

7 **Application integration**
Mobile equipment can be read by using fixed portals or mobile readers.
Tag protocols for oil and gas industry:
- UHF
- HF
- LF, new standard protocol for offshore

The different classes of equipment should be able to work together. Hence a reader intended for detection of human RFID for personnel leaving at the heliport should also detect if a mobile equipment RFID tag is passing through the same portal.

Security:
- Restricted access to the applications
- Access through procedures checking legality and likelihood of data
- Suspicious data is inhibited from being written and access is limited to read only
- Detection rate shall be close to 100%

Seamless integration with any companies ERP system is vital such as SAP, Workmate and MIPS etc.
- Automatic change of location in ERP system when:
  - Equipment move in supplying base
  - Equipment move to from supply base to transporter/conveyer
  - Equipment move from transporter/conveyer to platform

Transfer of data between the applications shall be based on any business need the individual operator may have.

The following business processes must be integrated:
- Information flow between client and suppliers in total value chain
- Standardization of marking requirements
- Supplier to mount RFID tags
- Standardization of information flow
- Common requirement for information flow

The solutions should be system independent and enable an interface to any companies ERP system.
All real-time information need to be available throughout the value chain and involved parties.

Common interfaces across industry are vital for the success in implementing RFID solutions. Common denominators are:

- Standardized technology such as frequency, hardware and software integration requirements
8 Appendices
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<th>Tags</th>
<th>Readers</th>
<th>Additional information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure and integration:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall infrastructure</td>
<td>See Additional information.</td>
<td>See Additional information.</td>
<td>Semantic web; “Internet of Things”; ISO/W3C standards; XML schemas/WITSML standard; Oil and Gas ontology; SOIL network (optional).</td>
</tr>
<tr>
<td>Data integration</td>
<td>See Readers.</td>
<td>Seamless integration with the ERP system.</td>
<td>ERP (e.g. SAP).</td>
</tr>
<tr>
<td>ID-numbering:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memory/ buffer</td>
<td>User definable (9-4kbytes, e.g. EEPROM).</td>
<td>Up to 400 tags, extension 2000 tags.</td>
<td></td>
</tr>
<tr>
<td>Programmable</td>
<td>Wireless activation/reprogrammable by proximity device (max. 5cm).</td>
<td>Program updates via host computer interface.</td>
<td></td>
</tr>
<tr>
<td>Air interface and related properties:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General annotations</td>
<td>Recommended:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard/Protocol/ Frequency</td>
<td>Global standard/ISM frequency band, (&lt;135kHz, 13.56MHz, 433MHz, 860-960MHz or 2.45GHz).</td>
<td>Tag compatible.</td>
<td>&lt;135kHz (ISO 11784/5, 14223, ISO/IEC 18000-2, RuBee, IEEE P1902.1); 13.56MHz (ISO 14443; 15693, ISO/IEC18000-3); 433MHz (ISO/IEC 18000-7); 860-960MHz (ISO/IEC 18000-6, EPC Class1/Gen2); 2.45GHz (ISO/IEC 18000-4).</td>
</tr>
<tr>
<td>Transmission Power</td>
<td>Depending on energy from reader.</td>
<td>Depending on frequency band and application.</td>
<td>Depending on frequency band, application and human exposure limits (passive tag applications).</td>
</tr>
<tr>
<td>Read range</td>
<td>See Readers.</td>
<td>Min. 35cm.</td>
<td>Min. 100%.</td>
</tr>
<tr>
<td>Detection accuracy</td>
<td>See Readers.</td>
<td>Min. 35cm.</td>
<td>Min. 100%.</td>
</tr>
<tr>
<td>Power</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power source</td>
<td>No battery, induced by the reader.</td>
<td>Non-replaceable/built-in battery. Min. 4 years @ 2sec intervals.</td>
<td>Rechargeable battery.</td>
</tr>
<tr>
<td>Battery indicator and backup</td>
<td>-</td>
<td>Low battery indication.</td>
<td>Low battery indication.</td>
</tr>
<tr>
<td>Environmental properties, incl. ignition protection in explosive atmosphere:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EX/ATEX</td>
<td>EX Zone 1.</td>
<td>See Tags.</td>
<td>EX Zone 0, 1 or 2 (depending on the localization of the portal).</td>
</tr>
<tr>
<td>Gas certification/ detector</td>
<td>Certification group IIC.</td>
<td>See Tags.</td>
<td>Certification group IIC. Gas detector, trip level 60% LEL (only EX Zone 2).</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>From -40°C to +85°C.</td>
<td>See Tags.</td>
<td>-40°C/+85°C or -40°C/+135°C (depending on the localization).</td>
</tr>
<tr>
<td>Humidity</td>
<td>100% RH and be non-condensing.</td>
<td>See Tags.</td>
<td>Offshore readers: Class T6 (85°C); Class T4 (135°C).</td>
</tr>
<tr>
<td>Material</td>
<td>Corrosion and fire resistant, low smoke, halogen free, withstands aggressive gases/ liquids and physical strain.</td>
<td>See Tags.</td>
<td>IP ?</td>
</tr>
<tr>
<td>Storage/ washing</td>
<td>Temperatures up to 100°C and sound hygienic.</td>
<td>-</td>
<td>DIN IEC 68-2-27</td>
</tr>
<tr>
<td>Shock</td>
<td>Withstand necessary shock exposure.</td>
<td>Up to 5G, multiple drops 1.5m.</td>
<td>Up to 3G, 20 sine cycles, 5Hz-150Hz. Noise 5Hz-1000Hz, 30 min.</td>
</tr>
<tr>
<td>Vibration</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Note! All prevailing regulations given by the authoritative body within the application must be followed, (Petroleum Safety Authority Norway, Norwegian Post and Telecommunication Authority, The Data Inspectorate in Norway, and Norwegian Radiation Protection Authority etc.).