Introduction

During pigging of the Statpipe in April 1999 an accident occurred in one of the gas trunk lines operated by Statoil. During launching of the ILI pig, the pig was mechanically damaged which later resulted in leakage of gas into the battery module while being in the pipeline. As a consequence a gas leakage into the battery module occurred and the lithium batteries exploded.
Statoil Pipelines Operations department requested the Statoil Safety Technology group to initiate a project to go through the various phases of a pigging operation to assess the risk elements involved and identify any Mandatory Regulations involved.
The independent research foundation SINTEF was engaged and the main objective of their project was to identify hazards related to the use of lithium batteries in pipeline pigs, and suggest corrective actions. This was achieved by executing an operational problem analysis (OPERA). The MagneScan XHR series from PII Pipetronix GmbH, which is our preferred tool fore use in very dry long lifetime gas pipelines, was used as a case.

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1.1 The main conclusion is:

Electrochem, which is the battery deliver, is a recognised battery manufacturer. PII Pipetronix has an acceptable design of the battery modules.
The probability of a critical accident is small.
The problem is the high damage potential to platform, pipeline, truck and supply boats together with human injuries if or when an accident occurs. Therefore, SINTEF suggest a number of actions to reduce the risk. The best solution would be to use alternative batteries. Use of e.g. alkaline manganese dioxide batteries or several types of rechargeable batteries has the potential for drastically reducing both the hazard and the battery costs. However the required power consumption in the pig has to be reduced due to less energy density.

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1.2 Continued use of Lithium Batteries

If lithium batteries still have to be used, SINTEF suggest actions like improved procedures, training of personnel, recommended fire-fighting equipment, warning and venting device during transportation, verification of safe battery mode through pipeline, improved launching and receiving verification, alternative diodes in the battery pack and robustness tests.
It is important to emphasis that the use of large quantities of lithium batteries for power supply in pigs is not a specific PII Pipetronix problem.

2 SINTEF Report

The SINTEF report, which is available upon request, covers all operations from the ILI tool leaves the Inspection Contractors shop until it is back in the shop and deals with the following subjects:

1. Battery Cells. Description of the main data and characteristics of the type of battery cell used.
2. Battery Packs: Description of and tabulations of the relevant data and parameters of the battery packs and battery modules of the PII Pipetronix MagneScan 20”XHR, 30”XHR and 40” XHR tools.
3. Battery Cells. Description of the failure mechanisms and environmental influence.
4. Regulatory and Safety Standards.
5. Operational Problem Analysis
6. Critical Findings
7. Recommendations

3 Statoil - Safety Technology’s Evaluation & Recommendations

3.1 Conclusion

The Risk introduced by the use of lithium batteries in ILI Tools is presently not handled in an acceptable way. It is recommended that the relevant experts and involved operation units establish necessary routines as soon as possible and make clear how technical measures can be prepared and implemented. The SINTEF Report provides a good basis for such actions.

3.2 SINTEF Report

The report *Risk analysis – use of lithium batteries in pipeline pigs* made by SINTEF establish the fact that use of lithium batteries of a volume required in an In-line Inspection Tool constitute a considerable accident potential.
The SINTEF report is identifying 30 possible operational problems, which may result in undesired events with respect to personnel injury, damage on material and functionality. From these 4 types of incidents have been assessed to have a high criticality, which is where serious consequences may occur or the frequency of occurrences is relevant.
Three of these incidents involve the Pipeline Operators personnel and installations directly:

- Lifting of ILI tool between the supply-ship and the installation.
- During performance of the launching of the ILI tool and the ILI run.
- During receiving of the ILI tool at the locoation of receival.

In addition one critical incident with high criticality is during transport from Vendor to Pipeline Operators facilities that will have consequences for 3rd parties:

- Transport of ILI tool on truck and ferry.

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3.3 Recommendations

So far the Statoil Governing Documents covering handling and operation of ILI in general terms only, special considerations and dedicated routines or instructions to cover the handling of Lithium Batteries or handling ILI Tools with Lithium Batteries are not established. The recommendations from Safety technology are hence as follows:

- Lithium Batteries should not be used if it is possible to utilize alternative, un-harmful battery types. This will basically be applicable to ILI operations that are of limited duration, or where the power consumption is limited.

- Routines and procedures for handling and use of lithium batteries and ILI tools containing lithium batteries must be established without delay. The procedure should cover all part of the handling and operations process in which Statoil is involved. The procedure should include how the open position of in-line valves is ensured during the pig passage through the valves. The procedure must also consider limitations for use of lithium batteries in pipelines with a temperature above critical.

- The possibility for developing and optimalisation of today's ILI tools in order to reduce the power consumption should be investigated. SINTEF have in their report pointed out a number of (tool specific) possibilities in this respect. In the long run it should be possible to reduce, eventually eliminate, the use of lithium batteries.

- All personnel who are involved in handling and use of lithium batteries and ILI tools with lithium batteries should be given a course in failure mechanisms and tool vulnerability.

- Contingency routines for handling of unstable and possible unstable lithium batteries must be established.

- Contingency routines for receiving of ILI tools where Lithium batteries have exploded or are unstable must be established.

- The pig-traps and the area are normally classified as Danger Zone 1. Lithium batteries in general is not accepted for use in equipment used in Zone 1.Whether the ILI tool in an intrinsically safe mode satisfy the requirements is unknown. This must be verified and eventual special efforts must be identified and implemented in the operational procedures.

- A system of monitoring the status of the battery module of the ILI tool in the pipeline, which will give a warning if the lithium batteries may have vented (due to internal overpressure in a battery cell), exploded or being in an unstable state, should be developed and implemented. The contingency routines and measures will thereby only be utilized if real danger situations occur.

- The battery modules should be equipped with a system that measure critical parameters such as temperature and internal pressure. If any danger threshold is passed this system shall trigger an alarm or warning to relevant personnel – truck driver, base personnel, supply ship crew or offshore or terminal facilities – and securing of the batteries/battery module in accordance with the established contingency procedures.

- Statoil must ensure that vendor and transporters is adhering to current Statutory Rules & Regulations and Safety Standards regulating transportation of lithium batteries and equipment containing lithium batteries. Any uncertainty of whether or not the current transports are in accordance with such rules and regulations must be cleared.

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4 Collection of experience data and facts

Statoil's section of Pipeline Operation has established a group who will do their utmost to handle the requirements and recommendations described above.
In order to collect facts of the use and handling of lithium batteries in ILI tools a questionnaire have been prepared that will be sent to potential and current providers of ILI services to Statoil.

Statoil are taking the liberty of addressing also fellow Pipeline Operators in form of a questionnaire, enclosed in Appendix 1. This is done in order to seek assistance and hopefully initiating feedback that can help all the Pipeline Operators and Statoil in an effort to establish relevant operational and contingency procedures that may affect and have impact on large part of the ILI and pipeline industry.

Statoil plan to share the lesson learned from the collection and analysis of the data. All data received will be treated strictly confidential and will not be disclosed to any third parties.

5 Appendixes

Appendix A: Questionnaire to Pipeline Operators

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App A Questionnaire to Pipeline Operators

Statoil kindly ask for your company's contribution to enable us to improve our HES routines. To Statoil the resent identified hazards introduced by the use of Lithium Batteries in ILI, contains new aspects to the performance of our In-line Inspection activity and hence is influencing the integrity management program established for the Pipeline Systems.

With reference to the above we hereby invite you to share with us any relevant input which may contribute during the recently started and ongoing action of establishing our own improved "Governing Documentation" related directly to the ILI activity or indirectly to the neighbouring and hosting facilities.

This Questionnaire is established by the Statoil's Pipeline Operations Department by Karsten Harneshaug and Torbjørn Staalesen. In case of a need for clarification of any of the questions is required please not hesitate to make contact.
The response to the questionnaire will be summarised and presented in the next meeting of the Pipeline Operator Forum

A.1 Experience with ILI tools

Q-1: Have you during handling at ILI Contractors shop, transportation or operation of ILI tools, powered by Lithium Batteries, experienced or observed any incidents related to the Lithium Batteries, such as venting or exploding?
A-1:……
Q-2: If yes, are you prepared, at a later stage, to advice us of the nature of incident and eventual consequences.
A-2: ……...

A.2 Procedures and instructions

Q-3: Have you established instructions describing storage and handling of Lithium Batteries?
A-3: ……
Q-4: Have you established instructions describing the storage and handling of Battery Modules containing Lithium Batteries?
A-4: ……
Q-5: Does your Operational Procedures cover the handling, storing and operations involving ILI tools powered by Lithium Batteries?
A-5: ……..

A.3 Contingency measures

Q-6: Have you in your emergency procedures descriptions of actions to be taken in situations where Lithium Batteries or similar reactive substances are in a hazardous state or unstable state during handling and operation?
A-6: …….

Q-7: Have you any "emergency hardware" mobilized during transport, handling and operation of ILI tools equipped with Lithium Batteries?
A-7: ……...

A.4 Transportation, tour and re-tour from Contractor's facilities via Operator's installations

What is your experience with your normal provider of ILI services?
Q-8a: Have they established instructions covering transport of Lithium Batteries (Dangerous Goods) by truck/train?
A-8a: ……..
Q-8b: If yes to Q-7a, do they meet ADR 2001 (European Code for transport of Dangerous Goods on Public Roads) requirements?
A: 8b:……
Q-8c: If yes to Q-7a, do they also meet RID 2001 (European Code for transport of Dangerous Goods on Railways)requirements?
A-8c: ……
Q-9: Do they meet the current IMDG (International Maritime Dangerous Goods Code) requirements?
A-9: …… …….

A.5 Sharing of information on the Lithium Battery topic

Q-I: Would you be prepared to discuss this topic and the above in a meeting at your premises?
A-I: ……
Q-II: Would you consider a symposium on this topic of any interest?
A-II: ……

Q-III: Would you know of any literature or papers on the topic?
A-III_ ……..

Q-IV: Have you any proposals to institutions or bodies who may have dealt with this or similar matter?
A-IV: ……..

Thanking you in advance for your response.

Please submit your reply, eventual opinions and related info to:

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