

Lesson learned from GH2: Tear of an H₂ hose in the cylinder pack handling

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Program and themes

1. Inspections on the SMS-PMA: operational experience, critical-technical systems and management factors
2. Inspection activity on a technical gas production site
3. Corrective actions following the inspection findings
4. Final considerations

1. Inspections on the SMS-PMA: operational experience, critical-technical systems and management factors

Inspections on the Safety Management System

The commission must verify the suitability of the **MAPP Document** and the implementation of the **SMS**, carrying out a **planned and systematic examination of the systems** being employed at the establishment, whether they are of a **technical, organizational or managerial nature**

The site operator must demonstrate

Has taken *adequate measures* to prevent any major accident

Has *sufficient means* to limit the consequences of major accidents inside and outside the site

The data and information contained in the SR, Notification, etc., *faithfully describe* the situation of the establishment

The information is made available to the *public*

Tools for the verification activities

- ❑ **Sheets of Operational Experience**: recording of events that have occurred in the establishment and in similar plants in the last 10 years
- ❑ **Checklist**: inspection checklist for verifying SMS-PMA elements
 1. Major accident prevention policy and SMS structure
 2. Organization and staff
 3. Identification and assessment of major hazards
 4. Operational control
 5. Management of Change
 6. Emergency planning
 7. Performance Control
 8. Control and review
- ❑ **Table of Events - Measures**: events hypothesized in the risk analysis, highlighting the critical technical systems involved

The inspection phases: input from operational experience

- **Phase I**: ... *preliminary documentation* ...
- **Phase II**: The Commission, based on the ***Sheets of the Operational Experience Analysis***, identifies critical issues of a management nature, with the support of the '***Events - Measures' Table***, proceeding with the analysis of the points of the ***Check List***, through documentary checks, interviews and observations of field activities both to internal operators and to third-party companies
- **III phase**: ... *final report* ...

Analysis of operational experience: technical and managerial implications

- ❖ The manager fills out the **form**, one for each significant event that **has occurred**, concerning the **SMS element** on the checklist
- ❖ The Commission proceeds with **the analysis** to identify the **factors** of each event that are found to be **deficient**, i.e. **not fully implemented** or **not adequate to the reality** of the site, focusing on **possibilities for improvement**
 - Technical Factors: update or modify the **critical component** regarding **list of elements**, maintenance **frequency**, procedures, Op.Instr.
 - Management Factors: more **difficult** to identify, **more effective** in **achieving** the inspection **objective**

2. Inspection activity on a technical gas production site

Production of technical gases: use of hydrogen packs

- Production of oxygen, nitrogen, argon by fractional distillation of air

Hydrogen packs

- Hydrogen (90 kg) used for the purification of Argon
 - The impure Argon (O₂) is sent to 2 reactors with catalyst where, thanks to the Hydrogen, it is purified from the Oxygen (with the formation of H₂O)
- Present 5 packs of 20 hydrogen cylinders of 0.05 m³/each (10 Nm³ each), charged to a pressure of 200 bar
- 2 packs connected to the distribution system control unit, via a 5 barg and 6 Nm³/h line, while the remaining are in standby

Risk Analysis: Release of hydrogen due to rupture of the 1/2" pipe at 5 bar

Operational experience sheet: “H2 hose tearing” event

Ref. ...	Date: ...	Title: Tear of an H2 hose	
<u>Brief technical description of the event:</u> During the movement of a pack of H2 cylinders, the operator, in order not to leave the hose hanging without support, hooked the hose disconnected from the empty pack to a pack in service . Once the latter was exhausted , when disconnecting it to move it, the next operator , not realizing the hose was attached, tore the hose . There was a little release of H2 (no trigger) with no injuries to the operator involved. The only damaged equipment was the hose connection			
<u>Critical technical systems:</u> //			
<i>Management factor</i>	<i>Description</i>	<i>Actions taken</i>	<i>Planned/scheduled actions</i>
Organization and Staff	Due to distraction , the operator leaves the anti-tear cable of the empty station attached to the package to be handled	Informing operators on the risks associated with the handling of H2 packs Modification of the fuel system to physically prevent operator errors	Installation of a wall duct to house the hoses of each pack and thus exclude the possibility of hooking the hoses onto other packs so as not to leave them hanging

The findings of the commission

- Lack of a **procedure for handling the pack of cylinders**, for the purposes of preliminary checks, operational activities to be implemented, etc.
- There is no **further information on the plant modification** following the event (point 5) and related **risk analysis** (point 3), as the manager treated it as **an action following the analysis of the causes**
- Furthermore, there is no **specification of the critical technical system** (hose connection)

The non-compliances that emerged (minor)

«Operating procedures and instructions in normal, abnormal and emergency conditions»

- ❑ Implement **specific Procedures and/or Instructions**, if connected to **events**, in order to **safely manage the preliminary control phases**, the correct **actions** to be implemented, the **closing phases of operations**

«Analysis of accidents and near-accidents»

- ❑ Review of the **"ACCIDENT REPORTING AND ANALYSIS"** procedure with description of **management factors**, **critical technical systems** and **planned/scheduled actions**, highlighting **safety reviews** and **risk analyses**, in the case of specific **interventions to be implemented on the plants** such as actions resulting from **the analysis of the causes** (Management of Change)

3. Corrective actions following the inspection findings

The staff training about the event

Safety meeting

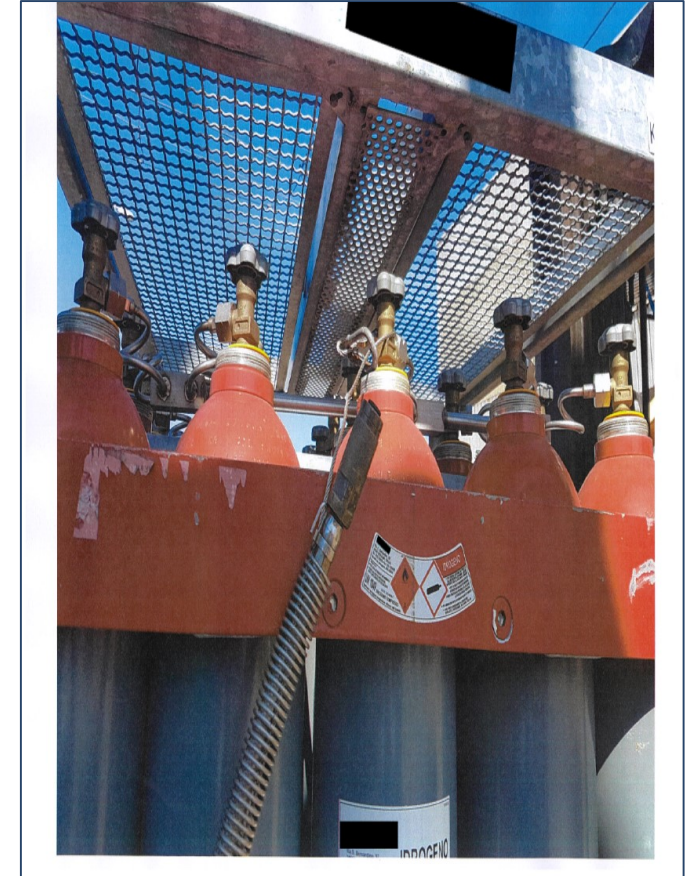
- *Presentation of analysis of accident occurred on the site*
 - *Documentation*
- *Minutes of the training session*

Sharing and dissemination

- *HSE managers and Supervisors*
- *Operators involved in the event*
- *Learning assessment and test*

Object of the discussion

- *Typology of accident (safety at work / process event)*
 - *Causes of the event*
- *Non-compliances and corrective actions to implement*



Management of Change: Modification of the fuel system

“Installation of a wall duct to house the hoses of each pack and thus exclude the possibility of hooking the hoses onto other packs so as not to leave them hanging (minimum possibility of human error)”

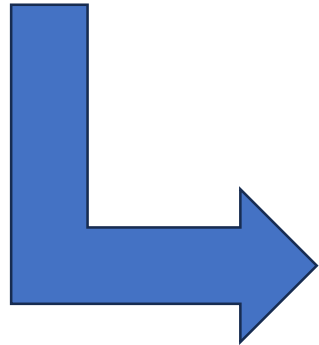
Registration of the Change has been prepared retrospectively in line with the provisions of the management system in force

- ✓ Report the actual dates of completion of the intervention, with the signature of the Manager in charge at the time of the event
- ✓ No further assessments and actions to implement emerged

The change registration form

Identifying the modification:

- *Typology and Title*
- *Responsible and Timing*
- *Motivation and Description*

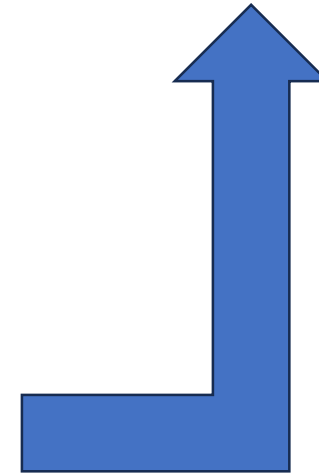


Evaluation of the modification:

- *Standard / Minor / Major*
- *Involvement of specific figures for risk assessment*
 - *Impacts and effects on Barriers/Measures and Procedures*
- *Signature of the verifying subjects*

First start check:

- *Safety review before start*
- *Documentation update*
- *Closing of the modification*



Implementation of the Operational Instruction

An **Operating Instruction** has been defined in the **Plant Technical Manual**

- ✓ Indication of actions to be followed in succession by the operator, so that the possibility of committing human error is reduced
- ✓ Information and training of all site personnel, in particular of the operators assigned to the activity in question
- ✓ Supervision of field activities by the shift leader
- ✓ Signs on the field, so that it can be consulted in case of doubts



The new Operational Instruction

Replacement of hydrogen **packs**: the main steps

- ✓ 2) Check pressure gauge and close valve
- ✓ 3) Unhook the hose of the pack to be replaced
- ✓ 5) Remove the empty pack and place the full pack using a forklift
- ✓ 6) Connect the flexible hose and opening the valve

1)



Before taking any action, check which ramp is actually in service using the arrow on the selector

4)



Do not attach the hose to other hydrogen packs

4. Final considerations

Minor events and safety culture

- ❑ Apparently **insignificant risks** are **underestimated** due to the **ease of execution and repetitiveness** of the operations (routine)
 - It is necessary to verify all the causes of accidents, as well as evaluate the impact of even the less significant and low probability ones
- ❑ **Operational errors**, in the case of **negligence and/or hurry**, are the effect of a corporate **safety culture not adequately developed**
 - Any "shortcut", to save time/money, combined with the lack of formalization of good practice, involves taking unnecessary risks
- ❑ **The commitment to safety of managerial** figures influences the **behavior** of workers, **overestimating** operational errors
 - Supervisors must monitor the correct execution of specific risk activities and Operators must demonstrate their knowledge through the use of correct work instructions and participation in training activities

Operational experience analysis: need for improvement

- **Exchange** of information on **accidents** that have occurred with establishments carrying out **similar activities**, with the support of **trade associations**
- Analysis of events, deepening the description of the related **management factors as well as the critical technical systems**, keeping track of them in the documentary analysis
- **Communication and dissemination of information** at all levels
 - Specific training sessions on the analysis of operational experience, carrying out specific learning verification tests
 - Updating/ refreshing of field training on Operational Instructions, especially if connected to specific events
 - Discussion of the findings at the review system meetings

If you think safety is expensive, try an accident



Questions ...???

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Thanks for the attention!

