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**Final Report
Safety Inspections of Galileo Charging station
Little Swan Project**

Plant: Charging and repair Unit
- Main line
- Small line (line No. 2)

Producer: GALILEO TP PROCESS EQUIPMENT S.r.l.
Via di Castelpulci, 17/M
50010 Badia a Settimo (Firenze)
Italia

Project: UNIDO-Project
Check of Charging units for i-Butane
in Little Swan Factory

TÜV Project-No.: 98 920

Responsible Experts: Dipl.-Ing. K-J Richardt-TÜV-Ulm-BB-NDD
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TÜV Süddeutschland Group

Location of inspection: Little Swan Electric Co. LTD
West Jiangjin Road
Jingzhou City / Hubei Province
P.R. China

Date of inspection: - 19./20.07.2002 – Inspection in Little Swan
- October 2002 till February 2003 receiving of
needed information and confirmations

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Mr. Qing Wei - Little Swan
Mr. Lambardi - Galileo TP
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1 General informations

TÜV Süddeutschland, Branch Ulm got the order of Galileo company of an inspection of the installed charging stations working with i-Butan.

Following parts are included in the inspection

1.1 Inspection devices

- a) line No. 2 (small line)
 - supply station Mod. RP 2-HC including 3 cylinders
 - Pipe to charging station
 - Charging station Habilis - H11
 - Repair station with Vortex isobutene discharging system
 - Safety control panel Cerberus
 - Safety installations (Gasalarm systems, Ventilations systems etc.)

- b) Marin line
 - Supply station Mod. RP2 - HC including 3 cyclinders
 - Pipe to charging station
 - 2 charging stations Frigus H 1-1
 - Repair station with VORTEX isobutene discharging system
 - Safety control penal Cerberus
 - Safety installations (Gasalarm system, Ventilation system etc.)



1.2 Scope of inspections

The undersigned experts inspected the devices mentioned in chapter 1.1 to find whether the installation is according to the international standards and the state of the art.

This safety-relevant evaluation covers the following components:

- pressurized components,
- components for the conveyance of flammable refrigerants,
- the electrical equipment of Supply system, FRIGUS H, HABILIS H, VORTEX and CERBERUS,
- the safety supervision system for fire and explosion hazards.
- the artificial ventilation system
- the technical equipment in the environment of supply area and charging stations

The evaluation is based on visual inspections, functional tests, measurements and a review of the technical documentation.

1.3 Exceptions of this inspection

Following were not part of this inspection.

There were no storage area of the used cylinders.

The refrigerators/freezers which use flammable refrigerants has not been inspected but must be in accordance with IEC 60 335-2-24, edition 4.1 and has not been inspected.



2 Documents used as a basis for the inspections

2.1 Applicable regulations

- EG directive 94/9/EG (Atex 100 a)
- EN 1127-1 Explosion protection, Fundamentals and Methods
- decree for pressure vessels
- Electrotechnical regulations: International: IEC / European: EN / National: DIN VDE
e.g. IEC 60073, IEC 439-1/A2, IEC 204-1, IEC 1310-2, EN 50054, EN 50054, EN
50013, EN 50020, EN 50081, EN 60529, pr. EN 1050, DIN VDE 0165, EN 349, EN
418, EN 294, EN 954-1
- Fundamental safety aspects to be considered for measurement and control
equipment: - Germany: DIN V 19250
- Safety requirements for automated manufacturing systems: Germany VDI 2854
- Personal protection regulations / accidents prevention
European: EN...EC / Germany: UVV/ZH, e.g.
VBG 1, VBG 5, VBG 20, VBG 21, VBG 61, ZH 1/200, ZH 1/266, ZH 1/8, ZH 1/10, ZH
1/134, ZH 1/455,
- Technical regulations for combustible liquids and for gases: Germany TRF / TRG e.g.
TRF 1996 / TRG 280
- Technical regulations for ventilators in ex-zones: Ex-proof / spark-proof for ventilators:
Germany VDMA 24169 Part 1
- Homologation of technical plant and equipment - European: conformity
certificates (e.g. PTB, Cesi)
- EN 378, Refrigerating systems and heat pumps, Safety and environmental
requirements
- EG machine directive (89/392/EEG, revised edition 91/368/EEC)
- IEC 79-10/EN 60079-10/VDE 0165 Part 101: Electrical apparatus for explosive gas
atmospheres - classification of hazardous areas
- IEC/EN/DIN VDE Standards; especially DIN 31000 / VDE 1000, DIN VDE 0116, DIN
57165 / VDE 0165, EN DIN 50014 / VDE 0170/0171.



2.2 Technical documentation available on site

1. Autotank 3
coolant supply system
Installation and users manual V1.0
- Angaben zu Ventil Nr. 7 pag. 5.3.1/5.3.3
2. RP2
operating and maintenance instructions
3. Habilis Model HP
Automatic Evacuating and Hydrocarbons
charging Equipment
Instructions for use and installations V3.2
4. MSA
- Control UNIT Model 9010 and 9020 LLD
- Ultima Gas Monitor
Test reports / Report of INERIS zu 00ATEX 0028X 008)
5. VACSOUND
D05, D08, D12, D18, D28
6. Vortex
Modul M
Isobutane discharging system for refrigerators
Installations + users manual V1.1
7. System Cerberus, instruction for use



3 General items of evaluation line 2 (small line) and Mainline

3.1 Technical measures

a) Generell safety strategy

- Implementation of a largely technically gas-tight Frigus HABILIS station, including the technically tight construction of the gas supply line up to the charging stations; as defined by the applicable technical regulations, technically tight connections include: undetectable joints (such as welded joints), detachable joints, such as mechanically sealing joints (cutting and clamping ring connections up to DN 32 as well as NPT or other taper pipe threads up to DN 50).
- Direct under the Hansen-coupling at the connection of the flexible isobutane hose of the charging stations with the feeding pipe a gas sensor is positioned.
- All sealing materials used are resistant to the gases used (neoprene, PTFE).
- Minimization of the maximum possible isobutane charging amount to about 50 g.
- Minimization of the isobutane amount inside the production area by positioning the supply stations with the isobutane bottles outside and closing the feeding pipe with shut off valves in case of gas alarm
- Avoidance of leakage caused by inadmissible overpressures within the system by means of pressure relief devices.
- Avoidance of ignition sources within hazard zones.
- Supervision of hazard zones by means of gas detectors in combination with safety function couplings.
- Definition of explosion hazard zones based on the implementation of efficient natural or technical ventilation within the hazardous areas (supply stations, metering system box, filling area, discharging area).



To avoid inadmissible overpressures in the supply stations, downstream of the supply pumps and the dosing cylinders caused by trapped gas in the liquid state, safety valves has been installed which prevents inadmissibly high operating pressures caused by thermal expansion of the liquid gas or malfunction of the pumps/dosing cylinders. In addition, suitable safety valves will be provided in the supply lines between the manual ball valve of the supply stations and the automatic shut-off valves at the entrance to the buildings and also at the end of the feeding pipes next to the connection to the charging stations (before Hansen coupling).

- b) On the realised concept the connections of the charging stations with the isobutane feeding pipes (Hansen coupling cannot be regarded as technical tight).

The surrounding of this connection with a radius of 20 cm around the Hansen coupling is defined Ex-zone 2, the conical area with a radius of 3.00 m by an upper cone point of 1.0 m above the connection is alarm zone.

- A limitation of this hazard zones are possible because of the gas sensor which is positioned direct under the connection (in case of 30% gas alarm switching off of the equipment inside the alarm/ex-zone and closing the shut-off valves in the feeding pipe).
 - During production time a leakage will be recognised. The manual ball valves which has to be installed before the connection to the charging stations (Hansen couplings) will make sure that out of production time the feeding pipe is closed (operator instruction necessary).
 - The switch on function of equipment's, which are placed within this Ex-zone 2, are interlocked with the safety supervision system.
 - Equipments which will be placed within this hazard areas, without an interlocking of the switch on function to the safety supervision system, must be approved for Ex-zone 2.
- c) On the realised concept of the recovery system (VORTEX) with 5 work cycles before the evacuation with the evacuation pump (see test report of Galileo TP from 12.10.00) on condition that the maximum isobutane charge amount is 50 g it is accepted to use a standard vacuum pump (not designed according EN 1012-2). According the test report with a residual isobutane amount of 0,8 g in the circuit in this special



case there is no ex-zone inside the pump and therefore no requirement for a vacuum pump according EN 1012-2. The results of the test report can be confirmed by the measuring of the gas concentration in the outlet of the pump during an evacuation process by the experts (< 50 % LEL).

d) Overpressure ventilation system

The system used to protect the electrical panel of the charging stations of FRIGUS and Habilis against explosion hazards is the pressurized apparatus – "p" - in accordance with Standard EN 50016. To implement this protection against explosion hazards, the electrical panel is constantly scavenged with air. Voltage can only be applied to the electrical panel when a predetermined prescavenging time (panel scavenging) has elapsed. The internal overpressure of the electrical panel is monitored automatically. A drop of this defined overpressure automatically causes the panel voltage to be cut out. The air for prescavenging the panel is taken from a zone without gas presence. The air removed from the panel after scavenging also must be led to a zone without gas presence.

Technical data

The overpressure ventilation system includes the following equipment:

- Fan
- Overpressure presence switch: adjustment > 0,5 mbar (overpressure set point 3 mbar according test calibration report)
- Internal volume of electrical panel and tubes H1 and H2: < 0.5 m³

The electrical monitoring of the overpressure ventilation system is realised by the ventilation panel and the CERBERUS system.



3.2 Organizational measures

- Operation of the charging stations and the discharge stations by skilled personnel according the instruction manual.
- Safety-relevant maintenance and inspection by experts at regular intervals.
- Workmanlike installation and commissioning of the plants by experts.

3.3 Definition of hazard zones

Ex-Zone 2

a) Isobutane supply area with following conditions:

- bottles and refrigerant transfer pumps with natural ventilation and gas sensor
- the conical area with a radius of 3 m around the pumps/connections, cone point 0,5 m above the couplings of the bottles

b) Isobutane charging and isobutane discharge areas with following conditions:

- Gas supervision and ventilation system (Cerberus) is on.
- the interior of the enclosure of the dosing systems of FRIGUS H and HABILIS H, with the installed gas supervision system and an efficient technical ventilation based on IEC 79-10
- the area with a radius of 20 cm around the Hansen couplings, the charging pistons and the recovery-piercing pliers
- the interior of the ventilation systems and the discharge pipes
- a circle with a radius of 2.00 m around the end of the ventilation channels and the discharge pipes at the open air.



Alarm-Zone

a) with technical ventilation in the charging/discharging area and the installed gas supervision system

- conical area with a radius of 1.5 m around the charging or discharging position, cone point 0.5 m above the coupled piston or coupled recovery piercing plier
- conical area with a radius of 1.5 m around the discharging unit (VORTEX), cone point 0.5 m above pump and the evacuation appliances
- the conical area around the connections of the charging stations with the isobutane feeding pipes (Hansen coupling) with a radius of 3.00 m by an upper cone point of 1.0 m above the connection

b) The Alarm Zone is defined as follow:

Defined area in which the formation of an explosive atmosphere is limited predictably in time and expansion by technical measures and potential ignition sources are automatically cut out before a mixture of gas and air reaches ignitability.

Technical measures in accordance with IEC 79-10 include:

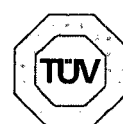
- All components carrying isobutane are permanently technically tight. If detachable joints are used, such joints must meet the above-mentioned requirements.
- The technical ventilation is dimensioned in accordance with IEC 79-10.
- An automatic gas warning system meeting the requirements of EN 50054/EN 50057 triggers automatic protective measures (fault message) upon detection of max. 15 % LEL isobutane and automatic emergency functions (automatic cut-off of all ignition sources) upon detection of max. 30% LEL isobutane.



- Within the alarm zone, only equipment which is indispensable for the operation of the charging system must be installed.
 - The electrical equipment within the alarm zone meets the requirements of the VDE/EN/IEC standards.
- c) For the alarm zone the following safety function couplings and safety strategy are realised:
- Gas detection "prealarm,, at 15% LEL with visual alarm, fault message.
 - Gas detection "alarm,, at 30% LEL with visual/audible alarm, cut-out of the refrigerant supply (shut-off valve), no alarm signalling to a permanently manned position because of permanent observation. Inside the alarm zone all potential ignition sources will be cut-off
 - Furthermore a special Isobutane-hazard switch with the same function as 30 % LEL is installed in the area of the charging station
 - The dimensions of the alarm zone are such that in the event of damage to refrigerant-carrying parts refrigerant set free outside the FRIGUS H or HABILIS H station will be detected and removed by suction ventilation system effective near the floor.

Fire hazard zone

- a) Isobutane supply room:
- a surrounding of 5.00 m around the supply room
- b) Isobutane charging and discharging/recovery area:
- a surrounding of 5.00 m



3.4 Safety data of the refrigerants

The following table shows the safety data of the eligible refrigerant:

Refrigerant	Ignition temperature	Temp. class	Density ratio (air = 1)	LEL / HEL	Boiling point
Isobutane	460°C	T 1	2.05	1.8 / 8.5 vol.%	- 12 °C



4 Test and Measure Results

4.1 Line 2 (small line)

Results of tests and Function tests and measurements were carried out by the TÜV experts on the system mentioned in chapter 1.1.

Tests

System component	Measuring result/Existing	Function conforming to safety strategy		Remarks
		yes	no	
1. Gas warning system prealarm 15% LEL Alarm 30% LEL System fault		x x x		
2. Hazard switch (special switches for fire and explosion hazards)		x		
3. Emergency stop switch		x		
4. Suction ventilation system				
– Stand by condition		x		
– Function coupling ventilation – charging/discharging		x		
– Pressure switch		x		
– Effectiveness of the area of the Alarm-zone		x		
– Door monitoring		x		
5. Pressure monitoring in the filler		x		
6. Emergency power supply				confirmed



Measurements

System component	Measuring result/Existing	Function conforming to safety strategy		Remarks
		yes	no	
1. Insulation resistance of electrical circuits	$> 50 \times 10^6$ ohms	x		
2. Electrostatic discharge resistance – Plastic ventilation hose	$< 10^8$ Ohm	x		
3. Resistance of ground/potential-equalisation – Charging and discharging stations – Filler	≤ 0.3 Ohm ≤ 0.3 Ohm	x x		
4. Electrical resistance of the floor: – storage area – supply stations – charging/discharging areas	< 20 kOhm ≤ 5 MOhm ≤ 5 MOhm	X x x		
5. Ventilation L1 (next Habilis) L2 (charging station) L3 (welding station) L4 (repair station)	V1 = 7,0 m/s V2 = 9,9 m/s V1 = 7,8 m/s V2 = 10,4 m/s V1 = 7,0 m/s V2 = 9,8 m/s V1 = 7,9 m/s V2 = 10,4 m/s	x		
6. Lightning arrester – storage area – workshop with isobutene plant	6.0 Ohm	x		confirmed



5.2 Main Line (line 1)

Function tests and measurements were carried out by the TÜV experts on the systems mentioned in chapter 1.2.

Tests

System component	Measuring result/Existing	Function conforming to safety strategy		Remarks
		yes	no	
1. Gas warning system prealarm 15% LEL Alarm 30% LEL System fault		x (x) x		
2. Hazard switch (special switches for fire and explosion hazards)		(x)		
3. Emergency stop switch		x		
4. Suction ventilation system				
– Stand by condition		x		
– Function coupling ventilation – charging/discharging		X		
– Pressure switch		x		
– Effectiveness of the panel with the charging equipment		x		
– Effectiveness of the area of the Alarm-zone		x		
– Door monitoring		x		
5. Overpressure ventilation-system (EEx-p) Electrical panel				



System component	Measuring result/Existing	Function conforming to safety strategy		Remarks
		yes	no	
- Preventilation	5 min	x		Correction from 30 sec to 5 min was necessary
- Pressure monitoring		x		
- Function coupling to voltage supply		x		
- Electrical wire-interruption		x		
6. Pressure monitoring in the filler				
- pressure-sensor		x		
7. Emergency power supply				confirmed
Measurements				
1. Insulation resistance of electrical circuits	$> 50 \times 10^6$ ohms	x		
2. Electrostatic discharge resistance				
- Plastic ventilation hose (suction of metering box and overpressure ventilation system)		x		
3. Resistance of ground/potential-equalisation				
- Charging and discharging stations	≤ 0.3 Ohm	x		
- Filler				
• H 1.1	10 kOhm	x		
• H 2-2	< 0.3 Ohm	x		



System component	Measuring result/Existing	Function conforming to safety strategy		Remarks
		yes	no	
4. Electrical resistance of the floor: – storage area – supply stations – charging/discharging areas	< 20 kOhm 70 k Ohm 70 kOhm	X x x		
5. Ventilation a) End of feeding pipe (valve, filler, etc.) b) Charging place 2 c) welding area d) fan 1 e) fan 2	V1 = 3,8 m/s V2 = 6,3 m/s V1 = 4,1 m/s V2 = 6,5 m/s V1 = 3,6 m/s V2 = 5,5 m/s V1 = 6,3 m/s V2 = 8,8 m/s V1 = 6,3 m/s V2 = 8,7 m/s	x		

5 Deficiencies

After the inspection the report File: Gal/Lit-PRC/02/02 were made.

After that the experts receive from Galileo explanations and pictures to proof that all the mentioned deficiencies have been solved.

Solutions were explained also during a meeting in Galileo workshop in January 2003.



6 Safety-relevant checks

6.1 For safety reasons, the following tests must be carried out regularly:

Plant	Kind of check	Qualification	Check time (at least)
– refrigerant storage – refrigerant supply stations – refrigerant charging stations – refrigerant discharging stations – periphery of charging/discharging station – emergency power supply			
1. Plant complete	visual check	CP	daily
2. Plant complete	technical maintenance	CP	monthly
3. Safety equipment e.g. ventilation, grounding system, gas-warning system	visual check	CP	monthly
4. Safety equipment e.g. ventilation gas-warning system cut-off valves emergency power supply	technical inspection	CP	monthly
5. Gas-warning system	calibration of sensors	CP	each 6 month
6. Plant complete	function test of safety relevant function	CP	yearly
7. Organisation - Records of checks - training of people	check the documents	CP Management	yearly
8. Plant complete	check of all safety relevant aspects	Experts	each 3 year
9. Essential changes of the plant	check of all safety relevant aspects	Experts	before run the plant again

CP = Competent people: Experienced people must have a special education of the plant and of the safety issues.

Experts: The experts are experienced in this field. They have additional the knowledge of a lot of different plants and also of the accidents which happened. They are independent and have a special approval by the government.



7 Conclusion

7.1 Conditions during operation of HC-charging station

During the inspection no iso-Butane has been used. After the report about the inspection were supplied to Galileo with all the detected deficiencies. It was stated together with pictures and explanations that all deficiencies were solved. Now the experts have no safety related doubts.

Little Swan must take care that the safety condition are always on this reached high level during the production with pentane.

7.2 Incidents / accidents

In case of special incidents and especially accidents (fire, explosion, human accident) the signed experts must be informed immediately.

7.3 Regularly information

The carried out TÜV-inspection is valid maximum till July 2005.

During this time the supervision by the experts will be realised as follow:

- The experts can get the yearly record of the internal competent people (CP's) of Little SwanGroup Co.
- The experts can visit the factory at any time e.g. on request of UNIDO.



7.4 Result of the inspection / tests

The HC charging and discharging stations and the HC-supply system at Little SwanGroup Co. were evaluated by the undersigned experts for observance of fire and explosion protection measures.

Measurements/tests in the supply and charging/discharging stations of GALILEO TP with the CERBERUS safety supervision system were carried out by the undersigned experts on the premises of Little Swan. Based on the visual inspections and functional tests carried out, the experts come to the conclusion that from a safety point of view the protective measures implemented for the avoidance of fire and explosion hazards reflect the state of the art if the general requirements in this report are met.

7.5 Certificate

At the TÜV inspection deficiencies and requested measures were detected by TÜV experts which are mentioned in report File: Gal/Lit-PRC/02/02.

After the experts got the explanation about handling of this deficiencies and measures proved by documentation and photos the expert can make the decision to issue a Certificate.

The Certificate TÜV-BB-UL-98 920 which based on this report File Gal/Lit-PRC/01/03 is valid until July 2005.

After that a new safety inspection is needed or the certificate will expire.

The Experts

Karl-Josef Richardt

Eberhard Mack

