Cryogenic and high pressure Gas Test for Valves

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High Pressure Gas Test

- Controlling the tightness of the valves is one of the most important technical demands facing the valve manufacturing industry

- To comply with the most stringent standard and technical specifications drawn by the users, and especially by major oil company, hydraulic and pneumatic test of the valves are definitely not enough to evaluate valve behavior in gas service at a specified temperature

- High pressure gas test of valves for transport and storage of gases is part of Valve Approval Test to verify the good performance of a valve under pressure

High Pressure Gas Test: “Test Fluid”

- Valve international standards regulate how the test has to be performed by the operators trained to conduct all the requested tests.

- Nitrogen is used in case of high temperature valve testing or in case of environmental temperature valve testing

- In case of cryogenic and low temperature, valves performance can be tested by a suitable gas testing (Helium, Nitrogen or Helium mixture).

Production or acceptance testing of standard production valves - representative samples (for example 10%) of valves are random selected for testing to check the performance at specified test conditions, but depending on the duty, critical valves can be subjected to 100% testing.

Cryogenic and high pressure gas test for valves

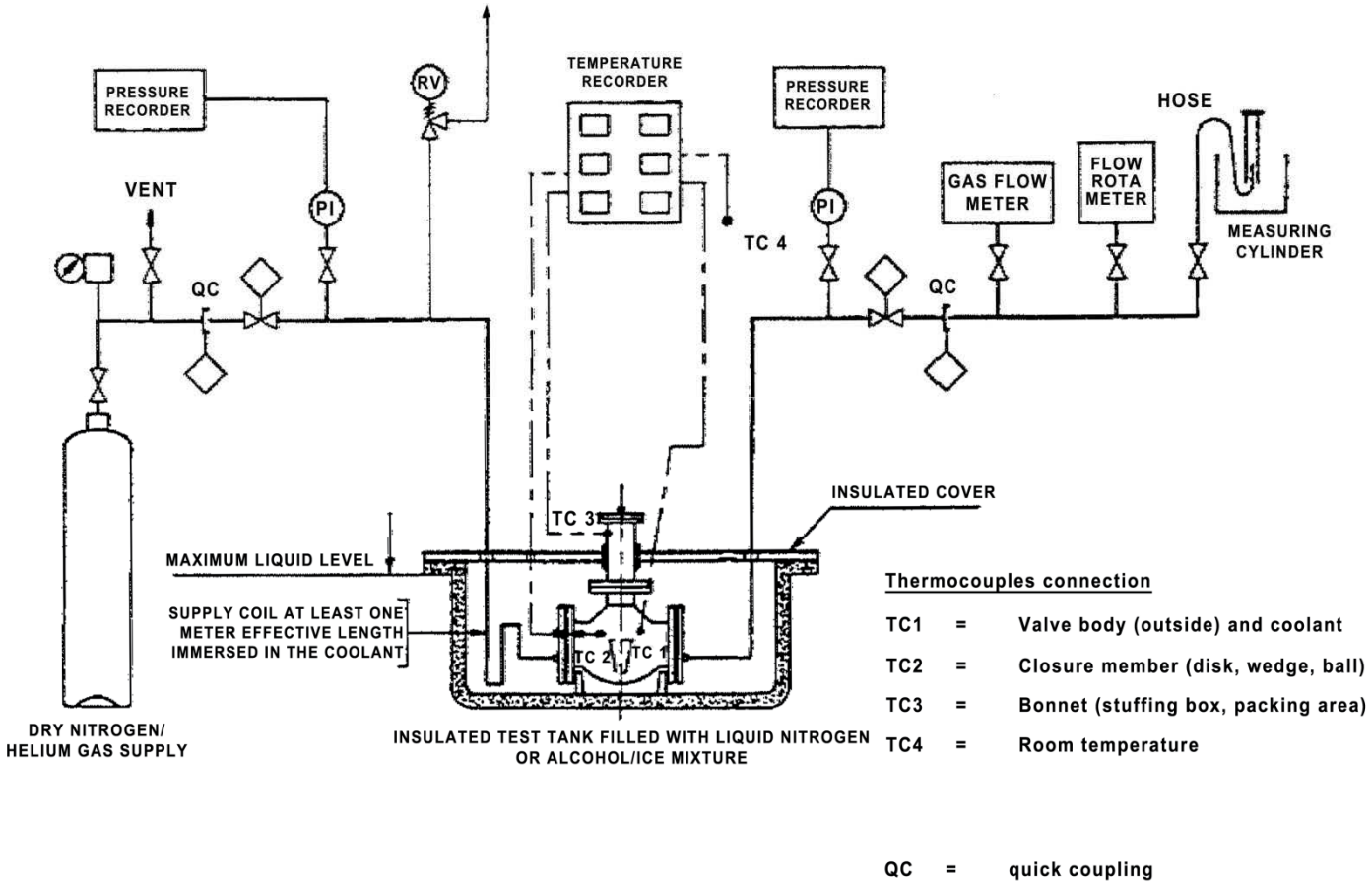


Fig. 3: Schematic of test-rig arrangement for type approval tests

Cryogenic Treatment: benefits

- Deep cryogenic treatment performed using liquid nitrogen causes microstructure changes that result in carbides precipitation during tempering phase with increase in both toughness and wear resistance

- Carbide precipitation depends on how long will be the cryotreatment: it increases extended holding time. Cryotreatment cycle is characterized by slow cooling (2,5℃/min) starting from environment temperatur e till -196℃, and holding time at cryogenic temperature. Once holding phase is complete the valve reheating takes place in still air

- Because of its advantages, valve components are subjected to this kind of process before of valve assembly

Cryogenic and low temperature gas tests: insulated test tank

- Valves cryogenic tests are performed in dedicated chambers that are filled with liquid nitrogen so as to reach the desired temperature. According to some specifications, the test must be conducted by submerging the valve body into liquid nitrogen, at a temperature of ca -196℃

- The testing process is controlled and managed by means of a system fitted out with a PLC to enable the tank to be filled with liquid nitrogen at a predetermined rate up to the desired level above body/bonnet joint

Cryogenic and low temperature gas tests: prior to testing (1)

- The valve has to be degreased, dried and assembled in a clean dust-free and grease-free environment
- Internal and external surfaces of the valves has to be free of moisture, dirt and metal particles

- The valve has to be carefully positioned into the insulated cooling tank prior to the admission of liquid nitrogen
- Helium or nitrogen purging has to be performed during cooling phase to ensure that all internal cavities are purged
- Liquid nitrogen is injected into the insulated tank up to the body/bonnet joint

Cryogenic and low temperature gas tests: prior to testing (2)

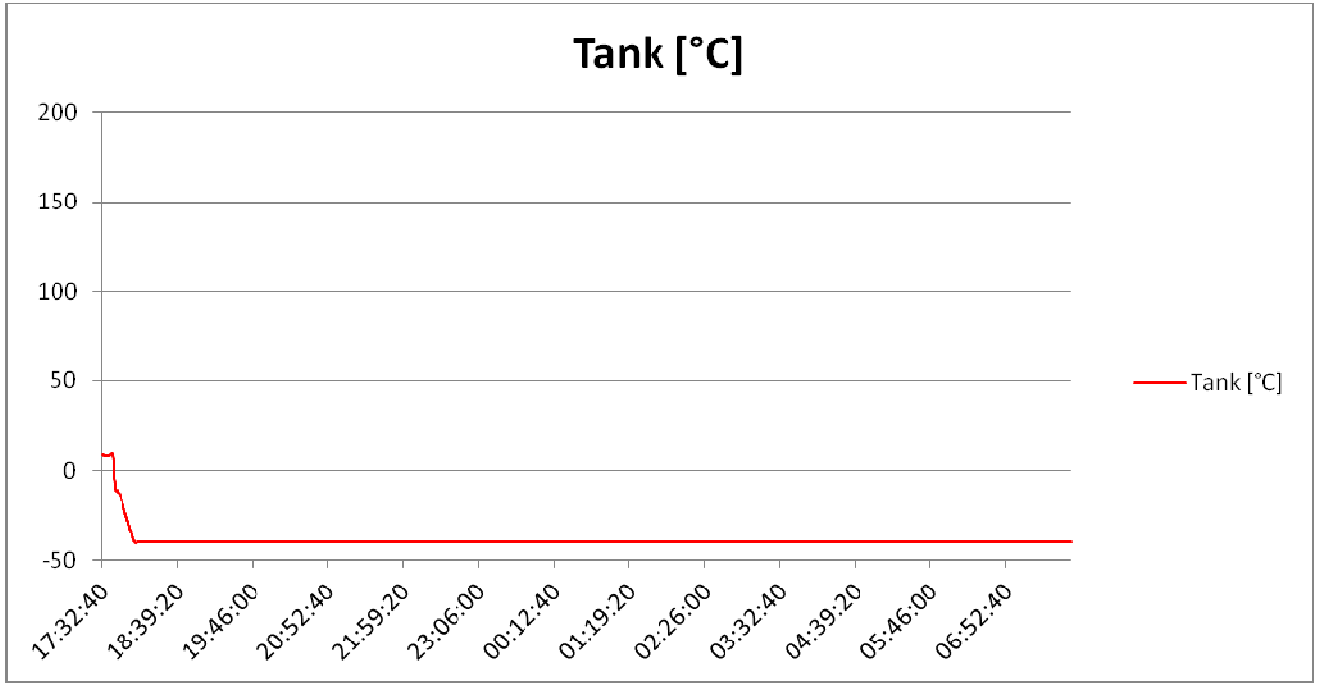
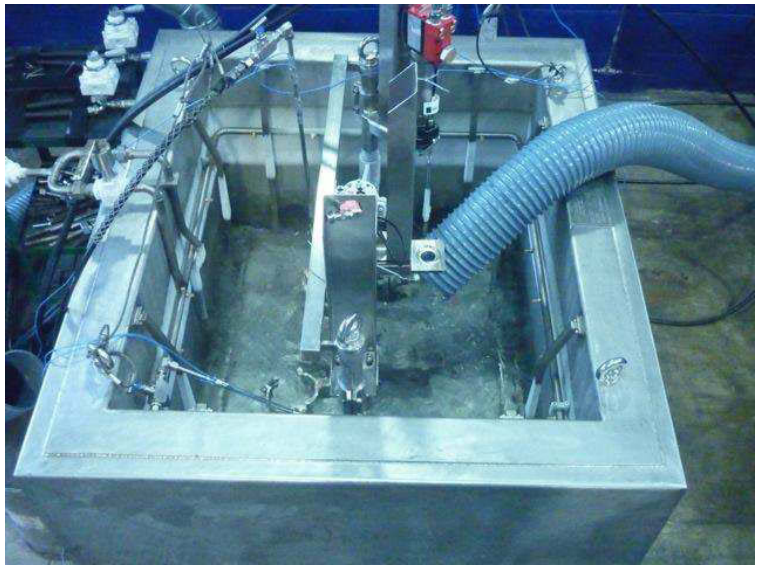


Fig. 8: Tank cooling and temperature control at -40° C by liquid nitrogen injection regulation

Cryogenic and low temperature gas tests: process parameters



- At least one thermocouple shall be attached to the valve body
- A second thermocouple shall be attached to the valve packing area
- A third thermocouple shall be installed inside the valve, close to the closure member

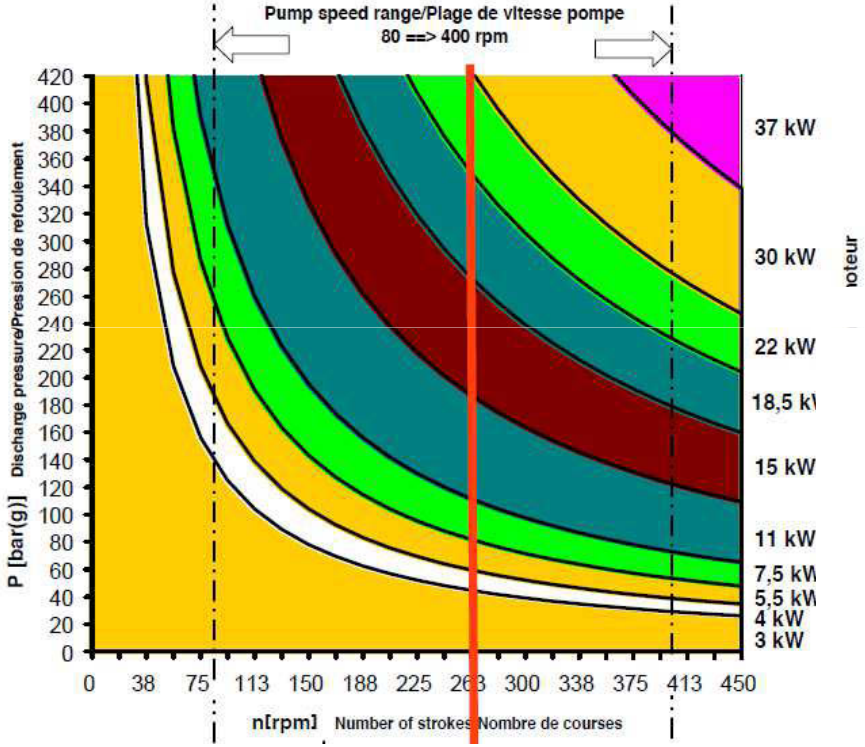
- Nitrogen and helium are the “test fluid” used. Control and management of these gases, or gas mixtures, to check the tightness of a valve is obtained by means of control panel equipped with gas boosters so as to reduce the time to reach the desired operating pressures (up to: 1600 barg)

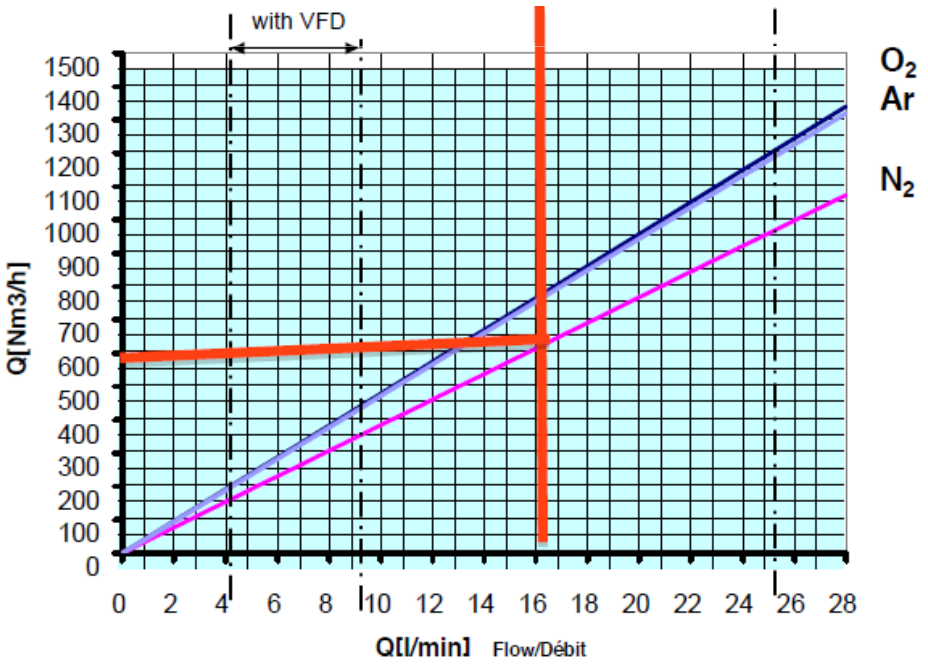
High pressure gas tests: nitrogen as test fluid

- The gaseous nitrogen entering the booster can be supplied either from bundles of cylinders or from a system equipped with a cryogenic pump and an evaporation system working at high pressure (up to 400 barg) and fed from a liquid nitrogen storage tank

- The use of a cryogenic pump to feed the system with high pressure nitrogen gas ensures the flow rates needed to greatly reduce the time needed to reach the required testing pressure in particular with increasing of valve size together with increasing demand of high pressure gas test made at different temperature

Cryogenic pump: performance diagram in case of nitrogen as test fluid





Valve cryogenic tests

- In case of valve test performed submerging the valve in liquid nitrogen only helium is used as test gas
- Once cryogenic test is finished, pressure has to be completely reduced and valve has to be reheat in still air
- Hot air blowers or heaters to warm up the valves is not allowed
- The valve shall be thoroughly cleaned, dried and visually inspected after completion of the test

Fugitive Emission Test

- “Fugitive emission” refers to any emission escaping from regulated processes (sources) other than via the designed release point (smoke stack, etc.). The point source for a fugitive emission is simply called “a leak”. These leaks and emissions are most often associated with the equipment necessary for the movement of process fluids and gases

- Fugitive emissions in the USA have been estimated to be in excess of 300,000 tonnes per year, accounting for about one third of the total organic emissions from chemical and petrochemical plants

- typically 50 to 60 % of emissions from a plant are attributed to valves

Valve cryogenic tests: fugitive emissions

- Only qualified personnel may perform emission testing
- Fugitive emission shall be measured with a mass spectrometer and the range of the leakage-measuring device shall not exceed 10 times the maximum allowable leakage rate
- The range of the pressure gauges installed shall not exceed twice the maximum test pressure. All digital indicators shall have full scale reading. All test equipment shall have a valid calibration certificate

Fugitive Emissions: “Test Fluid”

SEAT TESTS

- In case of T < -110℃ use 100 % Helium
- In case of T ≥ -110℃ use Helium or Nitrogen or Nitrogen + 1% Helium

BODY AND FE TESTS

- In case of T < -110℃ use 100 % Helium
- In case of T ≥ -110℃ use 100 % Helium or Nitrogen + 1% Helium

The test temperature shall be in accordance with the minimum design temperature. The test temperature shall be maintained within a tolerance of ± 5% or ± 5℃

Nitrogen storage and feed system to perform valves test (1)

The components of a system as standardized by SIAD may be summarized as follows:

- storage tank for nitrogen use in either liquid or gaseous form
- high pressure nitrogen gas feed system, complete with cryogenic pump and high pressure vaporizer
- skid for connecting the helium cylinders and the relative control instruments
- control system to set the parameters governing the injection of the gas mixture into the valve body
- “bunker” for positioning the valve to be tested
- sniffer to detect leaks and be able to certify the results of the test

Nitrogen storage and feed system to perform valves test (2)

Conclusions

- The market development of casting and forging valves operating in critical conditions, has forced valves producers to constantly perform tightness test of valve bodies according to the most stringent standards and technical specifications drawn up by the users and especially by major oil companies

- Special valves for cryogenic applications has to be subject to a dedicate “impact test” to verify toughness in temperature and pressure set conditions

- SIAD is able to determine and design the appropriate equipment to meet any specific requirements and testing conditions due to experience and high level knowledge grown up through several successful installations