ASVAD

ASVAD VALVE VALIDATION FOR ITS USE IN NUCLEAR POWER PLANTS

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ASVAD INTL SL
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1 OBJECTIVE.

The present document has as principal objective to present in an organized way the necessary information to demonstrate the capabilities of the ASVAD Valve to fulfill its safety function when it is installed in the accumulators. Another objective is to demonstrate its qualification as ASME Nuclear class 2 Valve, which allows its installation and use in the Nuclear Power Plants (NPP's).

The document intention is to demonstrate that:

a) The injection of nitrogen from the accumulators should always be avoided.
b) The plants current strategies may not be efficient enough.
c) The ASVAD valve avoids the nitrogen injection with high reliability.
d) The ASVAD valve complies with nuclear class 2 and is qualified for use in NPPs.
e) The ASVAD installation in the PWR plants will substantially improve its capacity to deal with postulated accidents.

The sections are organized as follows:

1. Initial introduction describing the nitrogen injection problem in plants with accumulators (PWR). This problem is not developed in this study because there is enough documentation published about it. The weaknesses of the current strategies to avoid this injection are also discussed.

2. Description of the ASVAD's valve operating principle, its internal configuration, its functionalities, and its design details, that allows it to provide a reliable solution to the problem of nitrogen injection.

3. Description of the design and manufacture processes.

4. Development and results of the ASVAD's valve validation program according to the current regulations. Its class 2 nuclear qualification is demonstrated.

5. Summary of the current regulatory rules and explanation of the reasons why the ASVAD valve has the feasibility and effectiveness of fulfilling the expected safety functions.

6. Final conclusion.

7. Annexed documentation.

The ASVAD valve is covered by several patents in several countries:

EUROPE nº EP3142123 B1 / RUSSIA nº RU0002666346 / UKRAINE nº UA 117963 JAPAN nº JP6434992 / USA (US-2017-0133111-A1) / China (CN106663477) / South Korea (KR10-2016-7031024).

2 INTRODUCTION.

2.1 The nitrogen threat, our internal enemy.

A nuclear reactor generates heat even if its nuclear reaction has been stopped for a long time. This residual heat must be removed by special cooling systems to maintain its integrity. In case this heat cannot be extracted, the temperature rises enough to generate explosive atmospheres of hydrogen, and ends with the core meltdown, and the possible release of radioactive substances into the environment.

Concerning the PWR reactors, in the event of total electric power loss, the only way to maintain the cooling of the core is by means of what is called "natural circulation". This physical process creates flows in the RCS (Reactor cooling system) by effect of the temperature difference between the heated outflow water from reactor, and the cool water returning from the steam generator. The steam generator is where the heat from the core is exchanged and extracted to the outside as clean steam. This steam can be dissipated into the atmosphere, avoiding a direct communication between the core and the external environment.

Systems designed to mitigate these accidents usually include, among others, a passive injection system of borated water to the reactor. Their mission is to recover the water level in the reactor to maintain the cooling and, additionally, to maintain the boron concentration in the water, to ensure an adequate shutdown margin to keep the reactor under the critical level.

This system consists of one or more accumulators containing a certain amount of borated water, which is pressurized with nitrogen at a given pressure. These accumulators are connected to the reactor through an isolation valve (always kept open) and two non-return valves.

Under normal operating conditions, the pressure in the reactor is higher than the pressure in the accumulator. Under these conditions, the non-return valves remain closed and no injection is performed.

However, after a depressurization accident, when the reactor pressure falls under the pressure inside the accumulators, this pressured nitrogen starts to inject the borated water to the reactor, until the complete emptying of borated water. Once emptied, the operator must close the isolation valves and stop this injection.

But there is a special accident - The total loss of electric power (SBO) accident- wich unleashes also the LOCA accident. This situation complicates a lot the accident recovery, as the control of the injection equipment is lost and these valves cannot be closed.

Therefore the pressure in the reactor continues falling until going below the accumulator’s pressure. However, when it empties, the pressurized nitrogen goes inside the reactor cooling circuit.

This nitrogen inside the cooling system does not have any adverse effect on the chemical or radiological activity of the reactor. However, that nitrogen is a non-condensable gas, which finally goes to the higher parts of the circuit, mainly the top of the steam generator tubes. This accumulation of non-condensable gas causes the disruption of the natural recirculation flow, which **is the only available way** to extract the heat outwards. The nitrogen greatly complicates the subsequent core cooling and substantially increases the chances of core melting.

The present study has not the goal to define or assess all the casuistry that the incondensable gases intrusion in the reactor cooling circuit can cause. For more information about the undesirable effects of incondensable gases in the piping systems, there is a specific bibliography about the subject.

This gas injection from the accumulators over the cooling circuits should be avoided as much as possible. Currently only three strategies may be taken:

a. The first strategy is to close the valve connecting the accumulator to the reactor when water injection ends. This strategy has several drawbacks: these valves are normally opened and permanently disconnected to avoid a spurious closure. It's necessary to energize them and give them the closure order. However, during accident scenarios without electric power, it would be impossible to close them. Even if it could be achieved by portable systems, isolation may be done either too soon, so that the borated water injection does not take place completely, either too late, when nitrogen already has reached the reactor.

   However, this strategy has a main drawback. These isolation valves are designed to work in the open position. But when they are closed, its closure is usually imperfect, and the valves **have some leaks**. While the nitrogen pressure of the accumulator is higher than the RCS's pressure, the nitrogen will continue reaching the RCS although at a lower speed.

   During the accident, it is highly probable that the containment building can remain contaminated during long time. During the subsequent accident recovery, this nitrogen will have enough time to enter into the cooling systems jeopardizing the core cooling. For these reasons, **this strategy cannot guarantee the avoidance of the nitrogen injection**.

b. The second strategy is to vent nitrogen to the atmosphere through the accumulator pressure relief valves. This strategy suffers from similar drawbacks as the previous one. Even more, because the involved valves are operated with pressurized air, and **the air supply lines are not prepared to withstand accidents**, so they cannot be trusted them to avoid the injection.

c. The last strategy is just maintaining the system pressure at higher value than the nitrogen residual pressure inside the accumulator. This strategy can be effective and can prevent the nitrogen injection. It suffers from similar drawbacks as the previous ones, because it depends on **the deployment of some active elements** as the FLEX pressurization pumps.

   Working at higher pressures means also higher LOCA leakage rates. This also implies that the emergency systems are working in a more demanding condition. An accidental depressurization, even if it were for a short duration, would mean the RCS nitrogen injection.

The main drawback of this strategy is **that it is just a temporary strategy while other actions are taken**. The RCS cannot remain pressurized indefinitely in time, since sooner or later the system will have to be atmospheric (even if this happen before, due to the accident itself). Then at this moment, the nitrogen injection will be produced anyway.

From the inventor's point of view, all the current strategies suffer from the same combination of circumstances that hinder its effective achievement:

- The use of **active elements** that must be deployed and connected.
- The use of **active installed elements** and subjected to the harsh accident environment or not specifically designed for bearing it (isolation/purge valves and the air pipes in containment).
- The need to develop all these activities by the **emergency organization** in different places and at different moments in time.
- All these strategies are **time critical**, they must be done **at the right time** and simultaneously over all the accumulators.

Therefore, it is evident the need for some automatic system, which prevents the unwanted nitrogen injection to the RCS, without requiring any external energy for its operation. Furthermore, the system must automatically recognize the appropriate time for its operation. This can allow its unattended operation, and also maximize the effect of the injection of cooling water to the reactor. This should also ensure that nitrogen does not enter into the RCS system.

In addition, the fact of having a passive system, which is simple, robust, automatic, and is permanently installed, will maximize the chances of its success over the various circumstances of the accident.

The problems that imply the presence of nitrogen (or other gases) inside the refrigeration circuits are not the objective of this study, since there is already a lot of documentation about it. Just by reading the NRC [13] GL-2008-1 and all the documentation generated by it, it can be enough to understand the importance of this threat.

It is also not our objective to get into deep analysis of the current strategies to avoid nitrogen injection. We will just comment its main weaknesses to compare it with the much higher chances of the ASVAD valve.

3 THE ASVAD VALVE

After recognizing the weaknesses of the current strategies to avoid the injection of nitrogen from the accumulators to the RCS, we did not just complain about this issue, but we took step forward to find another alternative system that could avoid this injection and that does not have the problem of the previous strategies.

The result of this effort has been the design of a new passive element (The ASVAD valve) that can effectively prevent the nitrogen injection into the RCS or other emergency cooling systems.

The ASVAD Valve is quite similar to a safety pressure relief valve, but with a reverse operation. This element does not release the pressure when a setpoint is exceeded, but it does when the pressure in the accumulator **falls below a predetermined value**.

This valve must be installed on the nitrogen side of each accumulator. Being subjected to the accumulator internal pressure, it can easily detect the end of the water injection and it's able to vent the accumulator residual nitrogen to the atmosphere **before it can enter the RCS**.

Basically, the ASVAD valve remains closed while the pressure in the accumulator is normal. Once the injection begins, the nitrogen expands in the accumulator as the liquid goes out. This leads to a continuous fall in its internal pressure. When that pressure reaches the predetermined setpoint, the valve opens and vents the residual nitrogen to the atmosphere.

Once opened, the valve will remain in that position permanently. This guarantees the complete depressurization of the accumulator and avoids any further nitrogen injection into the system.

3.1 ASVAD Operating principle

The ASVAD valve has a very simple design, since it basically consists of a pressure chamber (1) connected to the accumulator. This pressure chamber is closed with a hollow obturator (2). Joined with the obturator, there is an adjusting disc (4) and a spring (3) that exerts a force downwards trying to open it.

The basis of the ASVAD valve operation is in the imbalance between the forces exerted over the obturator. On the bottom side, there is the force exerted by the accumulator internal pressure. This force firmly pushes up the obturator keeping it closed.

On the upper side, there is another force exerted by a preloaded spring. This force is constant and pushes the obturator down trying to open it.

While the force exerted by the accumulator normal pressure (thick arrow) is greater than the force exerted by the spring (thin arrow), the obturator remains closed and static.

We can preset the spring force to a value similar to the force exerted by the accumulator pressure once the water injection ends and gets emptied, and when these circumstances are given, the strength of the spring can overcome the force done by the residual pressure and suddenly open the obturator.

Under normal operating conditions, the accumulator pressure exceeds the residual pressure (when accumulator is empty) with a ratio of 3 to 1. This implies that the force ratio will also be 3 to 1. This guarantees a completely stable closure while maintaining the normal pressure of the accumulator.

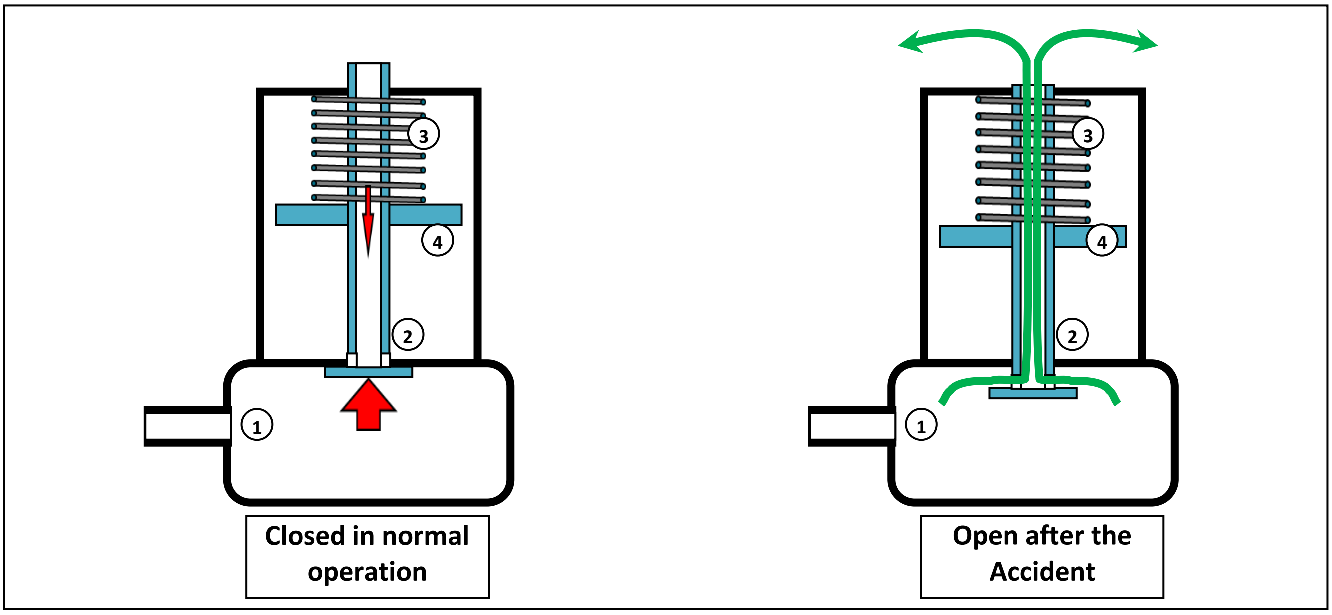


Figure 1. ASVAD valve simplified operation diagram.

During the accident, with loss of coolant (LOCA), and once the RCS has lost a good part of his pressure, the accumulators will start their injection. As the water flows out of the accumulator, the nitrogen inside expands, decreasing its pressure. This implies that the ratio of forces decreases each time, and progressively while approaching the unit.

Once the liquid phase has been injected, it remains a gas residual pressure that must be evacuated. When this pressure falls below the valve setpoint, the force of the spring surpasses the residual pressure force, and suddenly the obturator moves down from its seat opening the communication from the pressure chamber (1) across the holes of the inner hollow tube to the outside. Once the obturator has left its seat, the pressure in the chamber will fall even more, leaving the valve permanently open due to the continuous spring action.

This implies the total accumulator depressurization to the containment atmosphere, and thereby completely prevents the entry of this nitrogen into the RCS. As a secondary consequence, this expanding nitrogen will help inerting and cooling the containment atmosphere.

The adjustment disc (4) is threaded over the obturator (2), so that the initial spring strain can be adjusted in a certain range. This strain will mainly predetermine the pressure actuation point.

3.2 ASVAD valve detailed internal configuration.

The ASVAD valve design, while respecting its basic operating principle, has several additional features that complement its basic safety function. There are the remote actuation features (opening and closing), the anti-rotation system, the gas deflector, and its environmental protection. It is evident that the schema shown in figure 1 is just a simplification of the current design of the ASVAD valve.

The ASVAD valve detailed description that follows, is based on the schema RV-E1306-rev3 supplied as annex 1. The figure on the left represents the ASVAD valve in its closed position, while the central figure containing the references of each piece with the ASVAD valve is represented in its open position.

The ASVAD valve is defined inside a metal body formed by three main pieces:

- The central body (5), which contains the internal elements.
- The top cover (20) which contains the opening piston (1881).
- A lower pressurized chamber (25) where the main obturator is located and communicates with the accumulator through a standard flanged connection (173).

The ASVAD valve internal parts are the following:

- a main obturator (1047) which receives on its lower part, the pressure of the gas in the pressurized chamber which is associated with a regulating spring (1887) through an adjustable threaded disk (1884). This disc includes two anti-rotation studs (1895).
- A main sealing gasket (70) fixed with screws to the central body (5) and drawn in the Z detail. This gasket together with the main obturator (1047) closes the communication from the pressure chamber with the obturator central hollow.
- A series of internal parts used to fix and to position elements. The spring container (177), the inner cylinder (931) that contains the previous one and closes the intermediate body. The guide cylinder (1883) contains the main obturator (1047) and serves as a guide both to the obturator and the closing piston (1882).
- A closing piston (1882) with its recovery spring (1886) and its corresponding sealing joints, which will be responsible for positioning the main obturator (1047) at closure.
- An opening piston (1881) and its corresponding sealing gaskets that will be responsible for positioning the main obturator at the opening (1047).
- External gas exit holes mechanized in the piston (1881) and in the cover (20). These holes are closed with anitdust plugs (660).
- A gas deflector formed by a disc (1896) screwed into the interior of the lower pressurized chamber (25).
- Finally a series of threaded studs (375) with their corresponding nuts (380) to join the central body (5) with the pressure chamber (25).

3.3 ASVAD valve operation details.

Once the basic operation of the ASVAD valve is understood, we will show in detail the additional functionalities that the real valve has. We will continue making reference to the schema RV-E1306-rev3 supplied as Annex 1.

3.3.1 Automatic opening functionality.

The ASVAD valve's main functionality is to exhaust the residual gas remaining in the accumulators once they have injected all their liquid phase. This functionality must be guaranteed before, during and after the postulated DBA, OBE and SSE accidents.

This functionality is achieved by the assembly formed by the pressure chamber (25), the main obturator (1047) and its gasket (70), the adjustment disc (1884) and the regulation spring (1887) and its associated support (107), (931) and (5).

At its closed position, the normal pressure of the accumulator reaches the pressurized chamber (25) through the connection (173). This pressure is usually maintained around 45 Kg/cm2 (640 psi).

While this pressure is maintained in the pressurized chamber (25), this pressure will exert an upward force **Fc** on the surface of the obturator (1047) which will counteract and overcome the force **Fa** exerted downwards by the weight of the obturator (1047) and the adjustment disc (1884), plus the force exerted by the opening spring (1887). While **Fc > Fa**, the highest pressure in the pressurized chamber (25) will keep the obturator (1047) closed on its seat (70) indefinitely.

As we said before, the normal operating pressure is around 45 Kg/cm2 (640 psi), while the residual pressure that remains after the complete injection of the liquid phase is around 16 Kg/cm2 (228 psi): Then, under normal conditions the ratio between these forces is practically 3 to 1, which will ensure a perfect and stable closure during all the normal operation.

During the accident, as the accumulator empties, the gas expands and its pressure falls inside it. When all the borated water has been emptied from the accumulator, it leaves a residual pressure around 16 Kg/cm2 (228 psi). At this time, the force **Fc** exerted by this pressure will no longer be able to counteract the combined **Fa** force of the opening spring (1887) and the weight of the obturator (1047) and its annexes.

This makes the obturator (1047) slightly move away from the gasket seal (70), thereby starting a gas leak through it. This leak produces two simultaneous effects: on one hand it will further decrease the pressure in the pressure chamber (25) and on the other hand it will increase the pressure in the inner body of the valve. Both effects combined will trigger the obturator to reach its lower position in few milliseconds. Now there is a permanent open communication between the pressure chamber (25) and the inner body of the valve.

Given that the antidust plugs (660) are only fixed to the upper cover (20) by simple friction, once the pressure inside the valve increases enough, they will be expelled by the gas that is exiting the obturator, being the way from the accumulator to the atmosphere permanently open. This will involve the complete depressurization of the accumulator in a short time, eliminating the possibility that this nitrogen could be introduced in the RCS

The expelled plugs are linked together by a hard steel cable that will keep them together and tied to the valve body. This way, they cannot become dangerous projectiles, or debris that could disturb other systems. It also prevents them from getting accidentally lost.

3.3.2 Manual arming function (valve closing).

Once the valve is open, the obturator (1047) will remain indefinitely in its lower position, leaving the system open. This obturator (1047) can only be returned to its armed position by actuating the closing piston (1882) by injecting pressurized air through the inlet (1898). This air will cause the closing piston (1882) to slide upward and push the obturator (1047) through the adjustment disc (1884) until the obturator (1047) is closed again on its seat (70).

This position can also be maintained indefinitely while the entry (1898) is pressurized. It will keep the valve closed, allowing us to normalize the accumulator by pressurizing it again with nitrogen.

Once the pressurized chamber (25) already has a pressure value greater than the valve actuation point, the inlet (1898) can be depressurized. Then, the piston (1882) will return to its lower rest position by the action of the opposing spring (1886), leaving the valve armed again and ready for a new use.

Optionally, the assembly of a compressed air supply system can be avoided by taking advantage of the already installed systems. This piston can share the same air pipe that controls the valve used to pressurize the accumulator with nitrogen. Simply connecting both air pipes, the ASVAD valve will be kept closed when a supply of nitrogen is made to the accumulator. When the nitrogen refill is done, the air is released and the valve remains armed.

3.3.3 Manual opening function (valve opening).

If by operational or maintenance reasons, the accumulator depressurization is required, this action may be performed through the ASVAD valve, simply by actuating the opening piston (1881) by injecting pressurized air through the top entry. This air will cause the opening piston (1881) to push down, pushing the spring container (177) and the whole obturator assembly (1887, 1047, and 1884) until the valve gets open.

This position can also be maintained indefinitely while the upper entrance is kept pressurized. However, once opened, it is no longer necessary to maintain the pressure to the opening piston, since the obturator will permanently be opened by the depressurization of the pressure chamber (25).

At this point, the upper entrance can be depressurized. Then, the piston (1881) will return to its upper resting position by the simple action of the main spring (1887), leaving the valve permanently open.

This functionality can also be used to open the valve by other different means, such as:

- A passive pyrotechnic system that could be electrically activated from outside the containment building.
- An additional accumulator level detection system that could complement its basic functionality of trip-by-pressure.

In this document, these alternative functionalities are not developed. Hence, if carried out, they would require their own corresponding safety evaluation.

3.3.4 Pressure setpoint adjustment.

Adjusting the desired pressure actuation point in the valve is really easy. It is achieved by the relative rotation between the adjustment disk (1884) and the main obturator (1047). This action compresses the spring with a certain strain that will be the force that will open the valve at the desired equivalent pressure.

The adjustment must be made with the pressure chamber (25) depressurized and the obturator open (1047). It is also necessary to have both the upper cover (20) and the opening piston assembly (1881, 1885) removed.

Under these conditions, and by means of a special tool that engages with the crenelated on the upper part of the obturator (1047), the obturator (1047) can be turned in one direction or another. This rotation will tighten or relax the main spring through the adjusting disc (1884). This disc cannot rotate with the obturator (1047), given that it has two anti-rotation studs (1895) that prevent it from rotating.

The adjusted strain in the spring will decide the pressure actuation point in the valve. This strain will depend mainly on the elastic constant of the spring and its degree of compression. This strain can be controlled visually during adjustment by observing the anti-rotating studs (1895) that protrude through the holes in the spring container (177).

Once adjusted, a functional test must be carried out in a test bench to check the adjustment made until that adjustment is within the specified limits.

It should be noted that this adjustment is very insensitive to any valve manipulations, the important friction in the thread between the adjustment disc and the obturator will keep them in position at all times. The friction from the obturator (1047) to the deflector (1896) also helps to maintain the position locked.

Once in normal operation with the valve closed, its misalignment is also not possible since the obturator (1047) remains closed to the seal (70). Then, by simple friction prevents any rotary movement thereof.

3.3.5 Containment temperature self-compensation.

It is known that both, the temperature and the pressure in the containment building will increase considerably after a LOCA or HELB accident. The ASVAD valve must be able to withstand such conditions and maintain not only its own integrity, but also its functionality before, during and after such events.

The expected temperatures are not capable of causing damage to the valve since it is almost entirely metallic. The EPDM gaskets are the valve weakest element, but they are robust enough to withstand the accident conditions without losing its functionality.

However, the most important effect that will occur in the accumulator's injection system due to the temperature rise inside the containment will be the heating of the entire accumulator, and therefore the nitrogen pressure rise inside it.

This heating will imply that the proper point to exhaust the nitrogen will increase with the temperature. When temperature is around the normal working level (@ 45ºC) the pressure at which the accumulator become empty of liquid is around 16 Kg/cm2 (228 psi). When the temperature reaches 100 ºC (212 ºF), that internal pressure almost reaches 19 Kg/cm2 (270 psi), which represents near 3 Kg/cm2 (43 psi) more.

Since most plants have replaced the RCP's old seals (Reactor Cooling Pumps), by the new low leakage passive seals, the expected LOCA will not be higher than 11,4 l/m (3 gallons/m). This means that the temperature and pressure rise in containment will be rather slow, and therefore quite isothermal throughout the accident.

The design of the ASVAD valve, has taken into account this circumstance, and takes advantage of what a priori, might seem a drawback (the increase of the pressure in the containment). This pressure rise can be turned into an acceptable solution for this problem (the deviation from the optimal pressure point in the accumulators).

The ASVAD valve takes advantage of the extra force that the rising pressure in the containment exerts on the obturator upper surface. This force helps the spring to counteract the accumulator's pressure force. Then, the expected valve opening point will be raised above the normal value under normal environmental conditions.

That force depends on the dimensions of the main gasket (70). Then, a suitable choice of the gasket internal diameter, will imply a greater or lesser effect from the containment pressure on the valve opening point.

This additional force produced by the containment ambient pressure, will compensate by a large extent, the deviation produced by the temperature rise in in the accumulator, since the basis of both parameters is the same variable (the containment temperature).

However, the pressure evolution inside the accumulator is linear with the temperature, while the pressure evolution in the containment -which also depends on the temperature-, is done by following the vapor saturation curve, which is quite linear at low temperatures, but not from 70ºC (158 ºF) and above.

Even so, an adequate choice of the dimensions of these elements and the pressure setpoint, can achieve an adequate correlation within the temperature range expected during the accident (50 ºC to 130ºC) (122 ºF to 266 ºF). In these circumstances, the maximum deviation of the valve opening point, from the accumulator emptying pressure point can be limited to only ± 0,6 Kg/cm2 (9 psi) during said temperature range.

This opening point "auto-adjustment" functionality, will greatly facilitate the choice of the ASVAD valve optimal working point, and will obviously improve the response of the same during the accident conditions, optimizing the effective volume available for the injection in the accumulators.

The optimal opening point choice of the ASVAD valve is not the competence of this study, and will be carried out by end users.

3.4 ASVAD Valve Installation in the accumulator system.

The ASVAD valve is connected to the accumulator by a short pipe section with the appropriate diameter. The connection to the accumulator must be made in its upper part, on the gas side. Any existing connections can be used or they could be made.

It's highly recommended to install a manual isolation valve between the accumulator and the ASVAD valve. This manual valve will allow us to isolate it from the accumulator when performing maintenance.

The ASVAD valve has a low weight and volume, and it is qualified to be mounted directly over the pipe. Our recommendation is to support it to a fixed point (wall or support), instead of being supported by the pipe. This will further minimize the possible vibrations that it might receive.

If the remote control functions are needed, this installation will require a pressurized air supply and the corresponding pneumatic and electric circuits for remote operation. These functionalities are not related to its safety function. Therefore its specific design will be done by end users and therefore will not be discussed in this document.

The ASVAD valve can operate in any mounting position or orientation. However, its normal operating position is in vertical position. In this position, the effect of the spring and obturator assembly weight is added to the force produced by the spring and is included during the valve adjustment.

Other different mounting positions are also allowed, but in these cases the change must be taken into account when adjusting the firing pressure.

3.5 ASVAD valve Advantages.

The inherent advantages of this valve are very numerous and cover several different areas. This is the following summary:

Main advantages:

1. The ASVAD Valve will be available **all the time** after its installation.
2. **It completely avoids** the nitrogen injection.
3. It Is based on simple and universal physical principles (force & pressure).
4. **It Is fully passive**. It does not require external energy.
5. **It Is fully autonomous.** It does not need any operator assistance.
6. It acts at **the right time** and over **all** the accumulators.
7. It does it automatically by sensing the accumulator pressure. It is also able to adequate its opening point to the existing environmental conditions maximizing the accumulator’s water volume.
8. **It completely vents** the accumulator. There will not be further injection.
9. It allows the depressurizing of the RCS at lower pressures, which will **greatly facilitate the further accident recovery**.
10. It will **save the organization's efforts**, allowing to be focused on other recovery tasks.
11. **It does not interfere** with the normal operation.

Secondary advantages:

1. It is very **reliable** due to its **simple and robust design**.
2. It is **hard** enough to withstand the post-LOCA environment.
3. It is very **easy to be installed** in the system. It does not require a big modification.
4. It is easy to be licensed. It **does not add any new failure mode** different from those already analyzed.
5. It is **intrinsically safe**. No electromagnetic compatibility problems. no-necessary software. Cyber attack proof. Fire proof. It does not add any fire load. It is not sensitive to radiation, nor sensitive to moisture or even flood.
6. It is a nuclear class 2 valve. Not needed to be class 1.
7. **Its operation is easy**. It can act remotely when required.
8. Its maintenance is simple. **There is no wear**. It just needs a few spare parts. Minimum maintenance cost "Install & Forget". Its maintenance can be done in the repair workshop as it is easy to be removed.
9. It is also **easy to be checked**. It is very similar to checking a standard relief valve.
10. The desired actuating pressure is easy to be adjusted and checked.
11. **It is economic**. It does not need a complex and expensive system modification.
12. **Its qualified life is very long**. You will not need future investments. "Buy once, use it forever."

Below, all these advantages are explained in detail according to their scope.

3.5.1 During normal operation.

- Due to the aforementioned physical principles, the ASVAD valve **will remain permanently closed**, as long as there is enough pressure in the accumulator. This ensures that the accumulator's operability will not be altered during the normal plant operation.
- It **does not present appreciable leaks** that can put the accumulator operability at risk. In the unlikely event of nitrogen leaking to the atmosphere, it can be easily isolated from the accumulator and removed for maintenance without affecting the accumulator operability (by the manual isolation valve).
- When remote actuation option is installed, the valve can be operated remotely from the control room. This option requires the installation of an air supply system and at least two solenoid valves. Then, both orders (opening and closing) can be executed remotely. This can facilitate its operation even when installed where access is difficult.
- Being located on the nitrogen side of the accumulator, and at a higher level, there is no possibility of being affected by boron deposits that can compromise its operation. Even in the hypothetical case of an accidental accumulator overfilling that could reach the pressure chamber, its internal elements would not be compromised due to the seal produced by the obturator against the gasket.

3.5.2 During the emergency.

- While the ASVAD valve is permanently installed in the system, **it is available during the whole time** to perform its safety function. It does not have inoperability periods.
- The valve fully avoids the accident complications due to nitrogen injection, **unloading the organization to have to manage them**. Operators can redirect their efforts to other more relevant tasks.
- It is a **fully passive element** (type C). It does not require any external energy source. It will perfectly work during the whole accident given that the necessary energy for its opening is already accumulated in its main string. It works according to simple and universal physical principles.
- It is a **completely autonomous and automatic** element. It does not require any operator attention, nor any other associated system to perform its safety function.
- **Acts at the right time** and always when the water injection is finished. Since its opening point depends mainly on the accumulator residual pressure, it will only open when the pressure falls enough. This can only happen when there is low amount of liquid inside the accumulator or it is quite depressurized.
- It can also compensate the effect produced by the containment temperature rise. This temperature will heat the gas inside the accumulator rising its pressure. The containment environment will automatically rise the valve opening pressure point to compensate these circumstances.
- The water injection from the accumulators will be done simultaneously, since they start from similar levels and pressures, and they discharge to the same RCS pressure. Then, its emptying moment will also happen simultaneously. By installing the ASVAD valve in each accumulator, they will be individually protected from the nitrogen injection.
- Once actuated, it **will fully depressurize the accumulator**, avoiding any further nitrogen injections. There is no way to repressurize again the accumulators since the valve will remain permanently open after its action.

- The accumulators venting will help to inert and cool the containment. This venting, although the pressure inside the containment building might be slightly increased, does not entail dangerous containment pressurization.
- Its actuation can be easily detected and verified by the available instrumentation (accumulator's pressure, or containment pressure and temperature). This can be done even in the case of significant instrumentation miscalibration. The pressure change in the accumulator is so important that it will be easily detected. There will also be a small increase in the containment pressure, together with a foreseeable momentary temperature fall produced by the gas expansion.
- Once the nitrogen injection is completely avoided, the RCS can be depressurized to lower levels. This further depressurization will reduce the cooling leakage rate. This will also facilitate to injecting water at lower pressures, allowing to use other alternative means (fire pipes system, low pressure pumps...). THIS CAN BE ONE OF THE MAIN ADVANTAGES WHEN INSTALLING THE VALVE IN THE SYSTEM. There is no need to worry about nitrogen; and the pressure in the RCS can be reduced at lower pressures allowing an easier accident recovery.
- Working at lower pressures, will facilitate the emergency equipment operation in more relaxed conditions during the whole accident recovery (the fuel consumption will be lower, the hoses will be subject to lesser efforts, the flow rates will be lesser and will last longer, etc).
- The further RCS depressurization will also mean that additional systems will be available for recovery the RCS level. A clear example of this is the fire ring that could also be used in these circumstances at lower pressures. Even other lower pressure pumps that were available could be used instead.
- If needed, (and when the rest of the required elements can be aligned), it is also possible to use the direct path to the atmosphere of containment across the valve, to make further inertizations with nitrogen. This can also be used to prevent the containment pressure from falling below the normal atmospheric pressure.

3.5.3 Safety related features.

- Its simplicity and the physical principles on which it is based, makes the valve a **very robust and reliable equipment**. Its failure possibility is very low, since it is immune to most of the known fault precursors. Having a very simple design and an operation **based on universal physical principles** (pressure, temperature and force) maximize its reliability.
- Once installed and armed, it **will be available the whole time** and from the first moment. It does not have inoperability periods.
- It **does not add any failure mode** to the system other than those already analyzed. In fact, its design makes it intrinsically safe because as long as the pressure in the accumulator remains normal, the valve tends to remain closed all the time. See section 6 in regarding the detailed analysis of failures.
- Since it is a simple mechanical element, its qualification as a safety element is also simple.
- It will give a **decrease in the CDF** (Core Damage Frequency). By avoiding the nitrogen injection into the RCS, it also avoids its derived complications. Therefore, the core damage probability will be reduced. The specific values of this CDF reduction must be calculated specifically by each particular case, and do not fall within the scope of this document.

- Its low weight (53 Kg) (117 lb), makes the valve **quite insensitive to seismic effects**.
- The valve weakest elements are the gaskets. Only 2 of them perform a safety function. Since none of them work dynamically (they are completely static), they **can maintain its functionality** even in the case of suffering higher degradation in their elastic properties.
- Due to its design and construction, it is **intrinsically immune** to many of the postulated risks:
  - About the external pressure. It uses the ambient pressure for its own operation, so its affectation is already considered. It does not pose any risk to its structural integrity.
  - Very robust against the temperature effects.
  - Immune to radiation.
  - Immune to liquids or moisture.
  - Immune to accelerations in the X and Y planes. Very robust in the Z plane.
  - Immune to electromagnetic fields, it does not generate them either.
  - Immune to corrosion and chemical attacks. Stainless steel F316.
  - Immune to dust and dirt.
  - Immune to cyber-attacks, no software is necessary.
  - Immune to electrical discharges or other electrical phenomena.
  - Immune to fire and does not contribute as fire load.
  - Very robust against projectiles due to its hard and rounded body.
  - Does not include materials that can be easily radiologically activated.

3.5.4 Design.

- It is an element with a **very simple design**, and therefore **robust and reliable**.
- The valve only needs to be **nuclear class 2**, since it does not constitute a RCS pressure barrier (same as the accumulator injection system).
- It is a fully metallic valve (except for some sealing gaskets). It can easily withstand the aggressive environments that can occur during a LOCA accident.
- The non-metallic parts of the valve (gaskets), since they do not work dynamically, can **maintain its functionality** even with significant degradation. However, they also have a specified qualified life.
- Its design complies with **ASME** standards.
- All of its pieces are also very simple. They do not require special efforts for their manufacture and assembly.

3.5.5 Instalation.

- Its installation in the system **is very simple**. Only a connection to the accumulator and one manual valve is necessary (to isolate it during maintenance).
- The modification to the accumulator system **may be minimal**. When the remote manual control option is installed, it only requires a standard control system like any other pneumatic valve. This system is not required to be qualified.
- Its implementation has no negative impact on the existing installation. The valve does not add any failure mode different from those already analyzed for the system.
- Being a relatively small valve with a limited weight, it will not require strong seismic supports or a big free space around it.

- It can be easily adapted to the existing accumulator connections. It does not require an exclusive connection to the accumulator and it can share any of the existing connections.
- It can usually be installed in a radiologically non-compromised area that can facilitate its maintenance at any time even during normal operation.
- Its installation does not affect the critical path during the plant outages, since the accumulators are inoperable and practically depressurized during the entire outage.
- Given its simplicity, its installation cost can be small. **No further investments will be necessary**, since its qualified life is very long and its maintenance is minimal.
- Although its standard installation is vertical, its installation is also allowed in any other position, even inverted. When installed in a different position than the vertical one, the pressure trigger setpoint should be reconsidered.

3.5.6 Maintenance.

- Its simple design also facilitates its maintenance. The ASVAD valve can be easily disassembled in its components, being able to inspect all of them completely and over all its surfaces.
- Its adjustment and checking is very simple. It is similar to other standard relief valves.
- Being a completely passive and static element, its parts **do not suffer any wear over time**. The material quality of their gaskets only requires their preventive replacement according to its qualified life.
- The presence of an isolation valve allows it to be maintained even with the accumulator in service and without compromising its operability. This allows it to be removed and replaced by another ASVAD valve very easily (just if necessary).
- The subsequent revision of the removed valve can be done in the conventional workshop as it is very difficult for the valve to be contaminated neither externally nor internally. Even in the unlikely case that it happens, its surfaces can be easily decontaminated.
- **Its qualified life is indefinite**, since the material in which it is manufactured is Stainless steel F316. This ensures that it will be able to work during the rest of the plant life. On the other hand, it will usually not be subjected to aggressive environments that could degrade it. Special cases are the internal EPDM gaskets that will require their preventive replacement based on its qualified life.
- All these gaskets are internal, so they are protected from the external environment.

4 DESIGN PROCESS

4.1 Initial Design.

The initial ASVAD Valve design idea arose after a training session about the SAMG (Severe accident Management Guides) procedures that were being implemented in the Ascó NPP to cope with a severe accident. These SAMG guides, require to the organization to maintain the RCS pressure above the value of nitrogen injection (around 16 Kg/cm2) (228 psi), but below the maximum injection pressure that was able to give the "FLEX" pumps newly acquired for it (around 21 Kg/cm2) (300 psi). This narrow margin and the difficulties of maintaining it during long time periods led the inventor to ask himself if there would be a simpler way to prevent the nitrogen in the accumulator from reaching the cooling circuit.

After evaluating some initial ideas, he realized that by means of a standard pneumatic valve configured to be spring opened, it was possible to solve the problem. This can be achieved by installing the valve in the gas part of the accumulator and when opened, it would be able to empty the accumulator to the atmosphere of the containment.

To keep the valve closed during the normal operation, it is necessary to supply the accumulator pressure to the valve pneumatic actuator. The high pressure in the hood would keep the opening spring compressed and therefore the valve would remain closed as long as there is enough pressure.

During an accident the accumulator injects its liquid phase into the reactor. The nitrogen in the accumulator expands as the injection progresses, causing a continuous pressure to fall inside. If the valve spring is chosen with a certain strain, we can achieve that when the pressure in the accumulator falls below some value (which would match the value when the accumulator becomes empty), this pressure is no longer able to oppose the force of the spring, which will cause the rapid opening of the valve and the emptying from the accumulator to the atmosphere.

Seeing that this special disposition of the elements was able to solve this serious problem in a simple and autonomous way, the inventor continued thinking about the technical problems that this solution could have in its physical implementation. One of the biggest problems were that both, the valve pneumatic actuator and its membrane had to be very robust because they had to withstand the normal pressure of the accumulator (around 45 Kg/cm2) (640 psi). The spring had to be also quite robust and the seal as tight as possible.

After a process of finding solutions, the inventor came up with a configuration that, while maintaining functionality and the same operating principle, the volume of the chamber under pressure could be minimized. The new design was even simpler than the initial design, which made it ideal for fulfilling the assigned safety function. The membrane, the pneumatic actuator, and the standard valve were no longer necessary.

Now all the work was done by an obturator attached to the spring. With these elements it was enough to achieve the sought functionality. The inventor continued improving his initial design including a system of pistons that can open and close the valve. This system would give the valve an additional functionality to be able to operate it manually and remotely.

After that, and seeing all the commercial possibilities for the prototype, the inventor proceeded to request the subsequent patent that was expressed in the International Application PCT / ES2014 / 070383.

4.2 Detailed design.

With the initial design already in the patent process, the inventor contacted the Ringo Válvulas SL management team. This company is specialized in the manufacture of valves of all types and services, including valves for their use in NPP's.

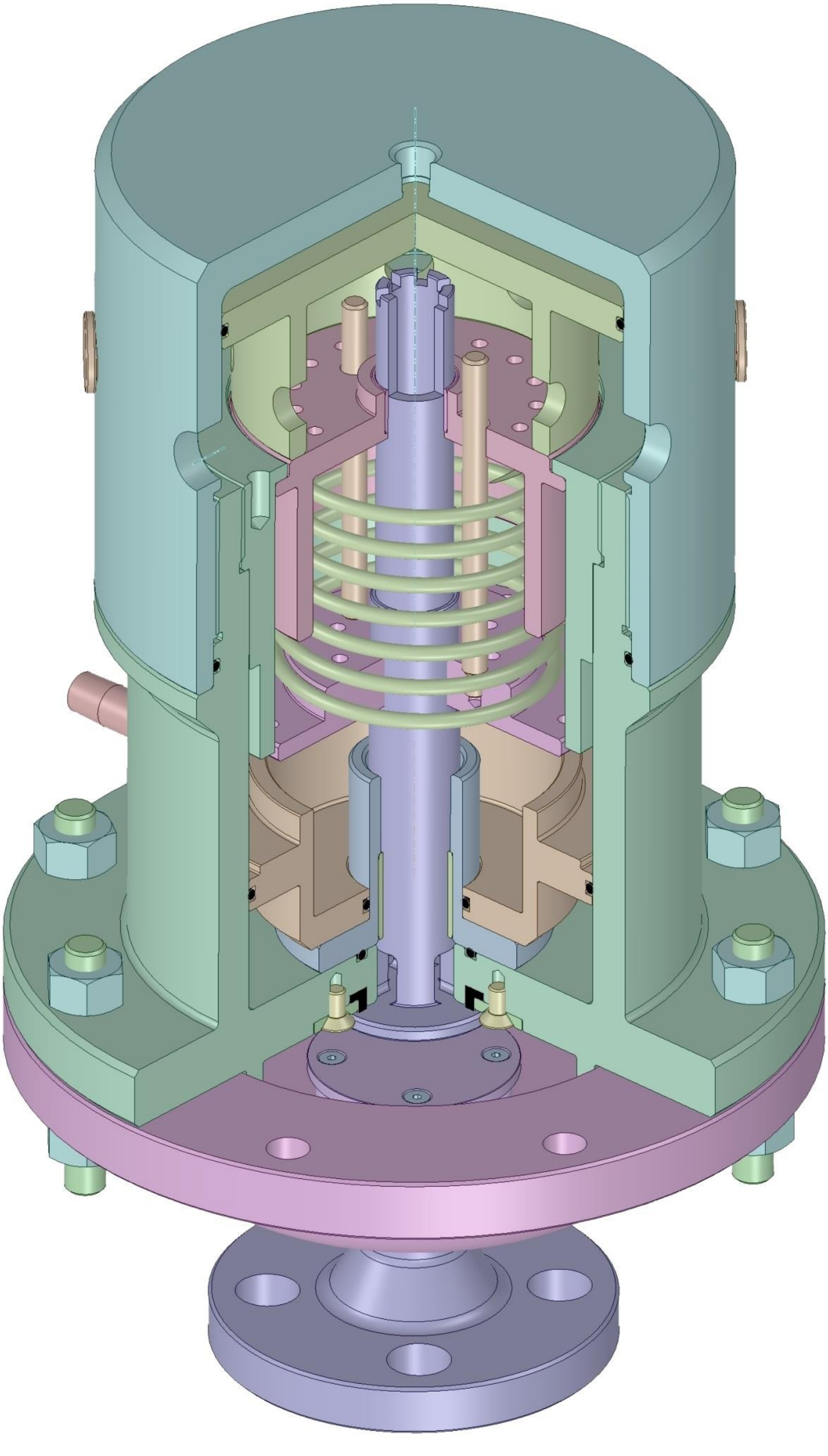
The Ringo Valves engineering team, advised by the inventor himself, made the valve ASVAD final design. Now this valve was able to meet with international standards, and could be subjected to a validation process and qualification to make it valid for its use in NPPs.

After the design process, we proceeded to the construction of a first prototype that could be subjected to the various qualification tests that are detailed below.
All these processes followed the internal procedures of Ringo Valves.

The result of this design is shown in detail in the document RV-E1306-3 included in Annex I which consists in the detailed schematics of the ASVAD valve. The following figure shows a 90 ° section in which all its internal components are shown.

We must indicate that the dimensions that are shown in the document can vary to accommodate the different specifications that are required by the end customers. Therefore, some parameters or parts of it may suffer dimensional variations.

The next revisions in the design, whether improvements to the initial design, or revisions to adapt it to other specifications, will take as a minimum, an analysis of the applicability of the results of this study. If the future changes were considered to be far-reaching, other specific study would be carried out for each case.



4.3 Asvad valve main features.

The main parameters that have determined the final dimensioning of the ASVAD valve are the following:

- Working pressure / temperature. It has been considered a working pressure of 50 Bar, and a working temperature of 130°C, which fits the valve in the category of # 300. All the thicknesses have been dimensioned following this criterion. Other categories may be available on demand. These would not require the complete requalification, since only some thicknesses would be modified.
- The internal diameter of the obturator. It is not a critical value, but 1" was chosen because it is similar to the pipes on which it will be mounted. Many dimensions of internal elements derive from this value. It only has an effect on the accumulator emptying speed, which is not considered an important parameter.
- Actuation range. Given that the pressure at which the accumulator is empty under normal conditions is around 16 kg/cm2 (228 psi), an adjustment range of ± 3 kg/cm2 (42 psi) was chosen around it. From this range, different parameters are derived, such as the useful surface of the obturator, the elastic constant of the spring and its dimensions. The dimensions of the main gasket have been chosen taking into account the surfaces subjected to the pressure of the accumulator on one side and the containment pressure on the other, in conjunction with the force exerted by the spring. Other ranges can be obtained by changing the main spring characteristics.
- The accumulator opening stroke has been set at 20 mm (0,8”). This value provides an exit hole surface > 1 ". From this parameter the dimensions of the arming piston, the length of the obturator and others are derived. It is a value that can also be varied depending on the needs of the end user.
- Pressurized air to the valve between 4 Bar and 15 Bar (58 to 217 psi). To adapt it to the standard compressed air pressures. The pistons dimensioning and its chambers are derived from these values.
- Thickness of the main pressure chamber and the neck of union with the flange. They were dimensioned taking into account the chosen ratio of #300 and the mechanical effects of an earthquake of 6G Vertical / 8.5G Horizontal.
- Material of the valve. The SA182 F316L stainless steel was chosen for its excellent mechanical performance and corrosion resistance.
- Nuclear Class 2. This valve is not a primary circuit pressure barrier. It fulfills the same class of the system in which it is installed.
- The opening point of the valve will follow the following formula:

$$Pdisp_{(n)} = Pdisp_{(0)} + RPDT*(T_{(n)} - T_{(0)}) + PA_{(n)} – PA_{(0)} - Rx$$

Where:

- $Pdisp_{(n)}$ is the opening pressure at conditions n.
- $Pdisp_{(o)}$ is the trigger pressure set at initial conditions.
- RPDT is the temperature drift coefficient from spring and determined during the valve manufacture.
- $(T_{(n)} - T_{(0)})$ is the temperature difference between the temperature in the condition (n) and the ambient temperature during the initial adjustment (0).
- $PA_{(n)} - PA_{(0)}$ is the difference between the ambient pressure in the condition (n) and the ambient pressure during the initial adjustment (0).
- Rx is the relaxation coefficient from the spring with the time and determined during its manufacture.

5 VALIDATION PROGRAM

To demonstrate the valve functionality during normal operating conditions and during the postulated accident conditions, the criteria indicated in the ASME QME-1-2012 standards [6] have been followed.

Specifically, the QR-5300 section of the ASME standards requires:

1. The drafting of a document that includes all the qualification criteria that the valve must meet, both in normal operation and in the postulated accident conditions.
2. The drafting of a series of tests or documents that demonstrate that the valve meets the qualification criteria indicated above by means of tests, analysis, experience or a combination of them.
3. The tests results to which the valve has been subjected, and which demonstrate conclusively the indicated criteria fulfillment.
4. The documentation generated for the fulfillment of the previous steps.

Since the ASVAD valve can be considered functionally equivalent to a safety relief valve (category B), these tests indicated in Table QV-7300 have been considered.

1. QV-I8000 Valve specifications.
2. QV-7650 Seismic Rating. (appendix QR-A)
3. QV-7660 Functional Qualification. (ASME chapter III, sub NC)
4. QV-7620 Environmental Qualification. (IEE-323/382 and appendix QR-B)
5. QV-6300 Leakage rating. (ISO 5208-2008)

5.1 Safety functions to validate.

There are just two safety functions that the ASVAD Valve must perform:

1. **Exhaust all the residual gas** that remains in the accumulators once they have injected all their liquid phase. This function is described in section 3.3.1.
2. **Keep the accumulator system tightness** until the moment of performing the previous function. This function supports the safety function of the accumulators system

   These functions must be guaranteed before, during and after the postulated DBA, OBE and SSE accidents. The rest of the functions described in sections 3.3.2 to 3.3.5 are just auxiliary functions to the main functions and are not safety related. Despite this, they are also included in this validation.

5.2 Components to qualify.

The qualification tests will be applied over the prototype ASVAD-1 manufactured by Ringo Valves SL for this purpose. The tests will be carried out to the complete valve as a whole. However, the components that intervene in the safety functions of the ASVAD valve are the ones explicitly described in section 3.3.1.

ELEMENT	SAFETY FUNCTION	
	KEEP TIGHTNESS	VENT THE NITROGEN
Input flange (173)	X	
Pressure chamber (25)	X	
Chamber closing gasket (330)	X	
Seal gasket (70)	X	
Main Obturator (1047)	X	X
Main Body (5)	X	X
Regulation spring (1887)		X
Adjustment disc (1884)		X
Spring container (177)		X
Locking cylinder (931)		X

All the other components perform functions that are not directly related to the safety functions.

All the metallic elements of the ASVAD valve are relatively simple to qualify, since they do not present degradation or affectation due to normal working conditions, nor for those derived from DBA accidents.

The ASVAD non-metallic elements are constituted mainly by soft gaskets made in EPDM. Among them, only the main seal gasket (70), and the chamber gasket (330) fulfills a function directly related to safety (providing tightness).

5.3 Qualification methodology.

The chosen methods for the ASVAD valve qualification are the following:

- **Test in test bench**. It will be verified through the appropriate tests that the prototype meets the specifications indicated both in the normal working conditions and in the specified DBA accident conditions. Therefore, the appropriate testing procedures will be developed.
- **By calculation**. This method will be used to qualify the Valve for seismic and vibration effects.

To carry out the validation tests, a test bench has been designed and constructed, whose dimensional and layout schema UT-A2-000230-0 is included in Annex II.

This test bench, with the associated heating and recording systems is capable of simulating from the normal work environment, to DBA accident and working conditions for those parameters that may influence the ASVAD valve operation.

Given that the external variables which can influence the valve operation are only the temperature and the ambient pressure, the test bench has been designed to be able to subject the ASVAD valve assembly to the pressure and temperature ranges that may occur during the DBA accident type in PWR power plants.

The set of qualification tests has been collected in a series of test procedures, which cover the ASVAD valve functionalities in normal operation as well as in DBA accidents. These procedures are attached in Annex III.

Test bench with the ASVAD valve after the DBA test

5.4 ASVAD valve specifications.

WORK PARAMETERS					
PARAMETER		**MIN. VALUE**	**MAX. VALUE**	**UNIT**	**COMMENTS**
Nominal Pressue	PN	n/a	50	Bar	
Workl temperature	T	0	50	ºC	
Ambient Pressure	PA	0,9	1,1	Bar (abs)	
Actuation pressure	PD	13	19	Bar	Variable, depending on temperature/pressure
Trip point uncertainty		-	±1% PN	Bar	
Leak flow	Fuga	-	0	l/min	Measured during 10 min.
Air pressure to close	Ppc	4	15	Bar	
Air pressure to open	Ppa	4	15	Bar	
Withstand Radiation		-	$<10^5$	rad	no affectation considered
Work Cicling		1	<500	cicles	
ACCIDENT PARAMETERS					
Maximal Temperature	Tmax	-	150	ºC	Withstand during more than 10 h.
Max. internal overpressure		-	75	Bar	Until 150% PN
Ambient Pressure	PA	0,9	5	Bar	Withstand during more than 96h
Humidity		0	100	%	no affectation considered
Radiación		0	>150	MRad	no affectation considered
Aceleration		-	6 (Vert) 8,5 (Horiz)	g	Obtained by calculations
Resonance Frequency			>52	Hz	Obtained by calculations
Temperature drift ratio	RPDT	0	≤0,025	Bar / ºC	(25ºC-150ºC)
Chemical spray		pH 4.3	pH 11		no affectation considered
Flooding		N/A	N/A		no affectation considered
DIMENSIONAL PARAMETERS					
Ratio		-	#300		Other ratios available on demand
Venting Diameter		-	1	inch	Other diameters available on demand
Hidraulic conection		-	DN25	-	Other connections available on demand
Weigth		-	53	Kg	
Volume		-	14,72	l	
Long		-	414,5	mm	
Max. Diameter		-	250	mm	
Main material		-	A182 F316L	-	
Gaskets		-	EPDM	-	
Qualified life		9 *	indefinite	years	* no metalic elements

5.5 Qualification Specifications.

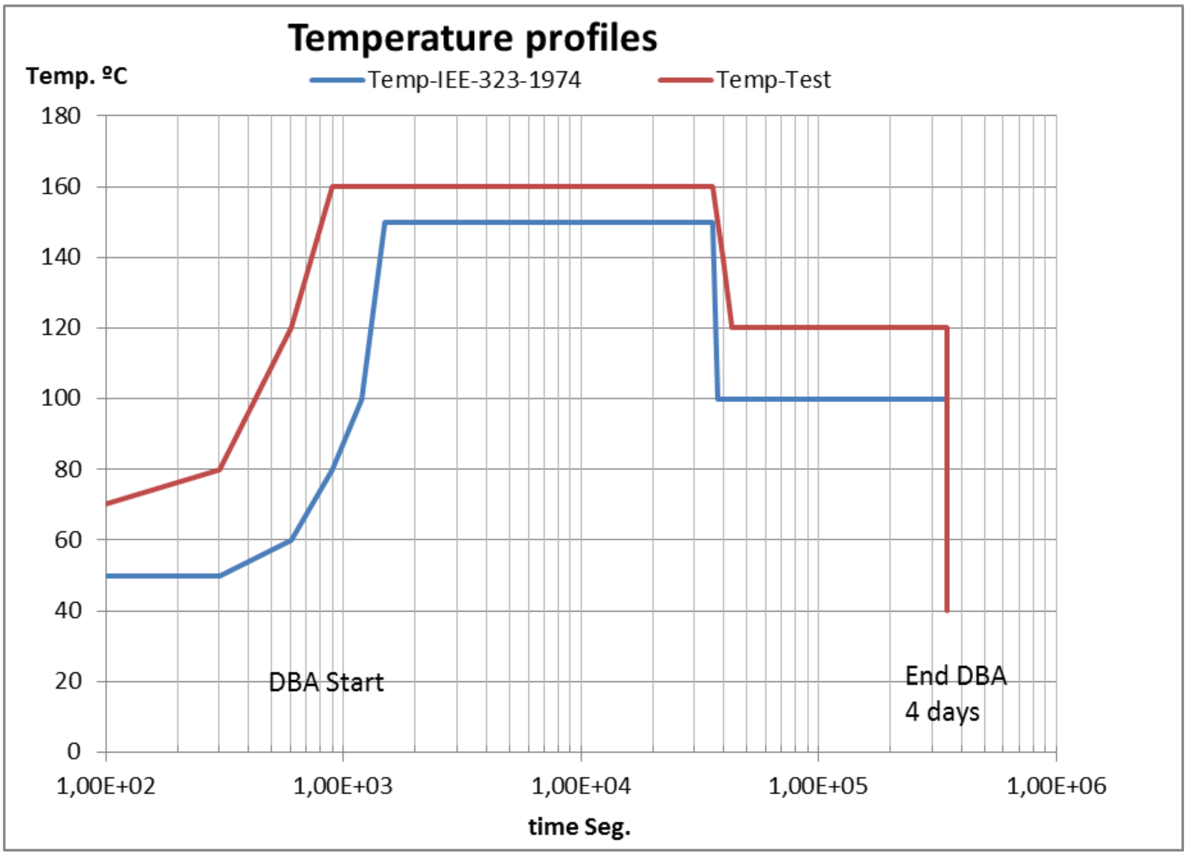
5.5.1 Environmental Qualification (Temperature).

According to IEE-323-1974 [15], the temperature profile to be covered is as follows:

0 – 10 sec.	48,9 ºC to 148,9 ºC	(120 ºF – 300 ºF)
10 sec – 10 hours	148,9 ºC	(300 ºF)
10 hours – 4 days	98,9 ºC	(210 ºF)
4 days – 1 year	75,0 ºC	(167 ºF)

Given the valve large thermal inertia that prevents a quick rise in its temperature, it will be considered that the zero time begins when the valve reaches 148.9 ºC (300 ºF). For the same reason, performing a temperature peak above 200ºC (392 ºF) and lasting less than 3 minutes is discarded. This profile is often considered in some environmental specifications.

Since it is considered that the valve actuation could be expected during the first 48 hours after the accident, the test may end after this time. However, depending on the leakage rate, the accumulators fully discharge can be delayed up to 24 h more, the test will be extended to cover twice the initial time: 96 h (4 days).



As it is intended to ensure an additional margin of 5ºC (9 ºF), the test will be carried out at a temperature of at least 5ºC above what it was specified during the entire period of the test. This ensures sufficient coverage of the DBA conditions.

5.5.2 Environmental Qualification (Pressure).

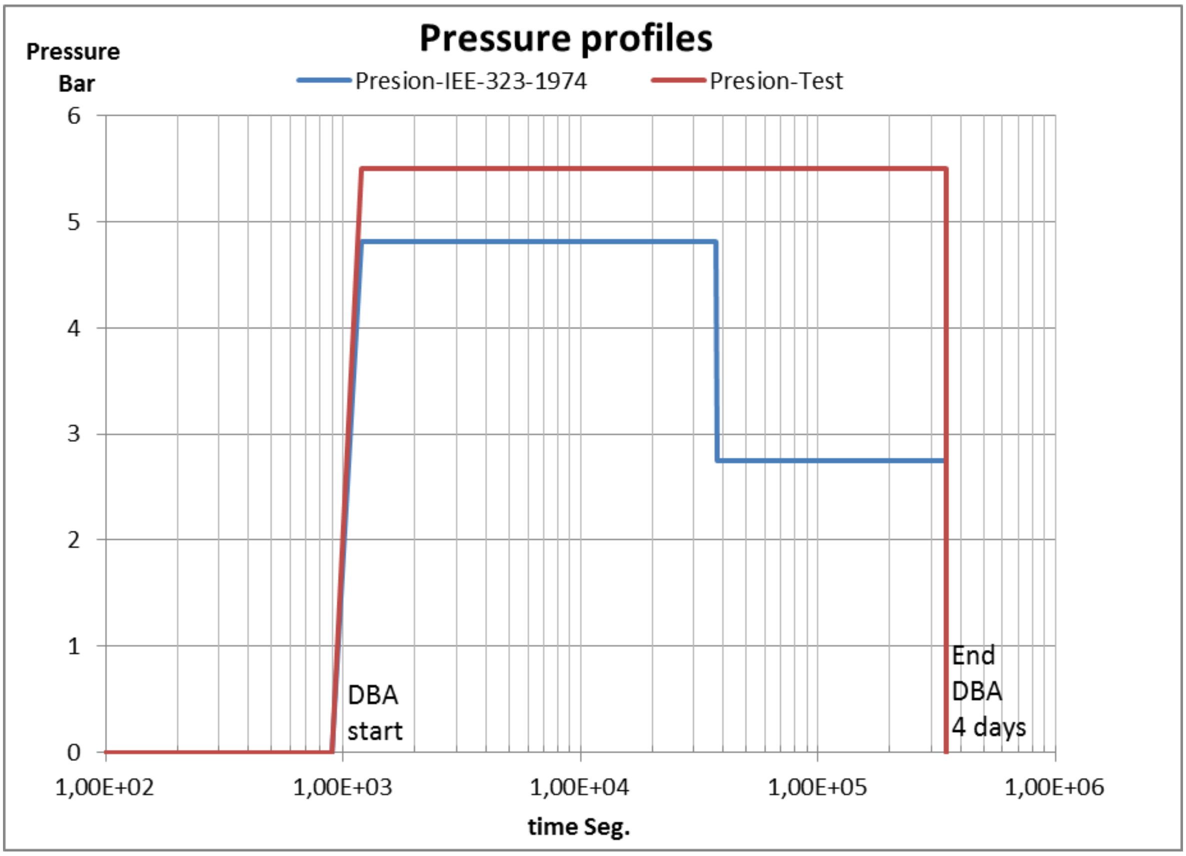
According to IEE-323-1974, the ambient pressure profile to be covered is as follows:

0 – 10 sec	0 a 4,82 Bar	(0 – 68,5 psi)
10 sec – 10 hours	4,82 Bar	(68,5 psi)
10 hours – 4 days	2,75 Bar	(39 psi)
4 days – 1 year	0,34 Bar	(5 psi)

Since it is considered that the valve actuation could be expected during the first 48 hours after the accident, the test may end after this time. However, depending on the leakage rate, the accumulators fully discharge can be delayed up to 24 h more, the test will be extended to cover twice the initial time: 96 h (4 days).

It is not appropriate to continue the test beyond the 4-day DBA period, since the environmental conditions become mild again, and the valve action will have occurred during the accident period.

As it is intended to ensure an additional margin of 10% equivalent to 0,5 bar (7 psi), the test will be performed at a pressure of at least 5,32 Bar (75 psi) during the entire test period. This ensures sufficient coverage of the DBA conditions.



5.5.3 Seismic Qualification.

The valve seismic qualification will be calculated by following the code ASME III Div.1 Subsection NC (Ed. 2007 addendum 2008) criteria [11] & [14].

Therefore, the following considerations will be taken:

- Vertical Acceleration: 6 G
- Horizontal Acceleration: 8,49 G
- Resonance frequency ≥ 50 Hz.

These values cover the totality of the OBE and SSE earthquakes in plants located in zones considered non-seismic and most of those considered with seismic risk. In any case, it will be the end user responsibility to verify that the indicated values meet their specific requirements.

In Annex IV, the Ringo Valves DC-6056-1 document is attached with the detailed calculations.

5.5.4 Environmental Qualification (other variables).

Since it is considered that the ASVAD valve is immune to:

- Radiation.
- Humidity, spray or flood.
- Corrosion and chemical attacks.
- Vibrations.
- Cycling.
- Fire.
- Dust and dirt.
- Projectiles.
- Electromagnetic fields.
- Electric discharges.
- Radiological Activation.
- Degradation / aging.

It is not considered necessary to carry out any validation tests on these variables. The next section details all the justifications and reasons for neglecting to perform specific tests on these variables.

5.5.4.1 Qualification by Radiations.

Since the valve ASVAD is near all-metal made, it is immune to the radiation effects. Then its qualification by radiation is not considered.

As for the non-metallic parts of the valve (gaskets), They are all installed inside the valve, so they are shielded from the radiation influence (α and β).

Given that the valve will be usually installed in an area with low environmental radiation (usually in the containment perimeter) it is not considered that these non-metallic elements can suffer aging for this reason.

For the same reason, and because during its operation it does not have any contact with radioactive fluids either externally or internally, it is not considered that these materials will be activated radiologically.

As indicated in the report EPRI-NP-2129 [9] talking about the EPDM material, it is capable of retaining 79% of its original tensile strength after absorbing radiation up to 10^8 Rads. These radiation levels are well above the radiation levels that are estimated to withstand during all its qualified life, which is around 10^4 Rads in 40 years.

Even in the hypothetical assumption of reaching these levels, the fact that the gaskets will not be subjected to dynamic efforts, (just withstanding the static pressure until the moment of its safety action), it ensures its very low sensitivity to this degradation mechanism.

During the accident, and although the radiation in the area can significantly increase, it will not have enough time to negatively affect the valve functionality before performing its action.

For all these reasons, the effects of radiation over the valve are not considered.

5.5.4.2 Qualification by moisture/flooding.

The ASVAD valve all-metal configuration (stainless steel A182 F316L) makes it immune to the effects of moisture, spraying and / or flooding, its qualification is not considered for these reasons.

Although the valve operates at atmospheric containment pressure by having direct communication with it, this is done through a hole of only 7mm diameter (.27”), which largely avoids the direct entry of water by splashing. Only a small amount can enter by some steam condensation inside.

Its installation in a high level over the containment basis also makes its flooding unlikely. To fill the containment building to the levels that could reach the valve level, it would require a much larger amount than available in the storage tanks.

Even in the hypothetical case of being flooded, the water presence in its interior would not impede its safety function, and the valve would remain fully available. There will be only a slightly drift in the valve opening point. This point would be increased by a residual amount corresponding to the water column weight. Each meter of water above the valve would provide an increase in the valve opening point of only 0,07 bar (1psi).

5.5.4.3 Qualification by chemical spray.

The ASVAD valve is fully metallic (stainless steel A182 F316L), therefore, it is immune to the effects of chemical spraying, its qualification is not considered for this reason.

As far as the non-metallic parts of the valve are concerned (gaskets), the material used is also particularly resistant to these effects. The gaskets are inside the valve, safe from chemical spraying. On the other hand, the fluid inside the valve is nitrogen at all times, and it is not expected that the borated water could reach the gasket except in the case that the valve was already open after performing its safety function.

Even under such conditions, the valve materials, including the non-metallic materials, are resistant to these fluids. For all these reasons, the effects of chemical spraying on the valve operability are not considered.

For identical reasons to the previous section, in the hypothetical case that some amount of said solution could enter inside the valve, the interior material is also resistant to corrosion and its functionality would not be affected either.

5.5.4.4 Qualification by vibrations and cycling.

Given the typical valve installation in the system, it is not considered necessary to perform any qualification to verify its resistance to vibration and cycling for the following reasons:

- The valve is closed during all its normal operation, and it only opens in accident conditions or during periodic functional tests. This practically cancels any adverse effects by cycling.
- The pipe that comes from the accumulator is not prone to transmit vibrations, since the accumulators are passive and static systems. There is no fluid movement or rapid changes in the pressure, nor in its normal operation nor during the accident conditions that may cause any vibrations.
- Only after its actuation, and once its safety function has been carried out, the pipe and the valve itself can be subjected to high gas flow rates. This is not a problem either, since the mass flow is very low as it is a gas and it lasts for a limited time.
- Even during the gas venting, it is not expected that this will cause significant vibrations either in the valve or in the pipe that supports it. This is due both to the low mass flow of the gas, and to the symmetrical arrangement of the outlet orifices. This symmetric arrangement will cancel the different reaction forces that can occur in each output, minimizing its mechanical stress for that reason.
- Despite all the above, the valve design is robust enough to efficiently withstand strong vibrations for extended periods of time.

5.5.4.5 Qualification by fire.

Since the ASVAD valve is entirely metallic, it is immune to the effects of fire (during limited periods). In addition, it does not contribute to any fire load and cannot become a point of ignition.

For all these reasons, it is not considered to qualify the valve by fire.

5.5.4.6 Qualification by dust and dirt.

Although the inside of the valve is communicated to the containment atmosphere, this is done through a small hole of only 7 mm diameter (0,28”). The valve has eight plugs closing the outlet orifices that can guarantee that neither dust nor dirt can be introduced inside the valve during normal operation.

In the event that any dirt is introduced during routine maintenance of the valve, it could only have an adverse effect if it reaches the main seal surface. In that case, the valve could present leaks that could be easily detected and corrected.

However and given that throughout its normal operation this seal remains completely closed, it is impossible for any dirt to be introduced in this area, even if the sealing of the valve is lost for some other reason.

For these reasons, it is not considered to qualify the valve to these circumstances.

5.5.4.7 Qualification by projectiles.

In relation to the possible projectiles produced by ruptures in high energy pipes, the ASVAD valve is not susceptible of being affected by them, given the valve intrinsic robustness, together with its small volume and rounded shapes.

The valve cannot be a source of projectiles either. Only during its actuation, the closing plugs in the outlet orifices will be expelled at high velocities. But these plugs can only cover a small distance (<5 cm) (2”) around the valve because all of them are tied to each other by a stainless steel cable that prevents any major travel (and also their loss).

For these reasons, it is not considered to qualify the valve by projectiles.

5.5.4.8 Qualification by electrical & electromagnetic efects.

Since the ASVAD valve is entirely metallic, and has no electrical or electronic circuit, it is immune to these effects. For the same reason, It cannot generate any electromagnetic fields, nor produce electrical discharges to the surrounding elements.

For these reasons, it is not considered to qualify the valve by these circumstances.

5.5.4.9 Qualification by degradation / aging effects.

The ASVAD valve is fully metallic (stainless steel A182 F316L). This makes it immune to normal degradation / aging effects,

Non-metallic elements are separately qualified since they may be susceptible to temperature aging. The qualification tests include a period of accelerated aging to simulate the effect of aging during normal operation.

Given that the valve will not be subjected to high temperatures, high radiation doses during normal operation, or mechanical stress different from the simple static pressure, it is considered that there is no possibility of synergistic effects between these degradation mechanisms.

5.5.5 Accelerated aging process.

To simulate the qualified life span for the non-metallic elements of the ASVAD valve, the prototype will be subjected to an accelerated aging period of 15 hours, maintaining its temperature at 120ºC. These values are intended to simulate an operational aging of 9 years, which is the qualified life that has been considered for the valve non-metallic elements.

The accelerated aging process is carried out within the testing procedure IN8-3-697, attached in annex III.

According to the Arrhenius formula,

$$t2 = t1 * exp\left[\frac{\theta}{k} * \frac{T1 - T2}{T1 * T2}\right]$$

Where:

- $t1$ is the operating time under normal operating conditions. A working time of **78.840** hours = 9 years has been chosen.
- $t2$ is the necessary aging time in hours.
- θ is the activation energy in eV (used **1,35 eV** [10]).
- k is the Boltzmann constant (**8,617 E-5** eV / K).
- $T1$ is the temperature under normal operating conditions (**323,15** ºK = 50ºC)
- $T2$ is the applied aging temperature (**393,15** ºK = 120º C).

Substituting:

$$t2 = \mathbf{78.840} \ * exp\left[\frac{\mathbf{1,35}\ \mathrm{eV}}{\mathbf{8,617\ E-5}} * \frac{\mathbf{323,15 - 393,15}}{\mathbf{323,15 * 393,15}}\right]$$

It results: $\boldsymbol{t2 = 14,1\ h}$

5.6 Qualification test plan.

A test plan has been designed that verifies compliance with the Valve design specifications, and its ability to withstand the operating conditions postulated during a DBA accident. This plan follows the directions given in IEEE 323-1983 [8].

Said set of tests will demonstrate that the design and execution of the ASVAD valve is suitable for its use to avoid nitrogen injection from the accumulators to the RCS and in particular for its rapid opening when the pressure in its chamber decreases below a specific value preset by the mechanical strain in its spring.

Given that the most limiting elements in terms of qualified life are the non-metallic elements, it is intended to demonstrate a qualified life of 9 years for them. For this, they will require accelerated aging by temperature according to the Arrhenius equation (see detail in section 5.5).

The plan for the tests execution is developed in the attached document IN8-3-695 and will be as follows:

1. Initial Inspection.

2. Initial functional tests at room temperature.
    a) Overpressure and leakage test.
    b) Piston actuation test
    c) Trigger test (ambient pressure) (5 series).

3. Initial functional tests at temperature and pressure.
    a) Opening test at 40ºC (5 series) ambient / 1,12 bar (abs).
    b) Opening test at 100ºC (5 series) ambient / 2,00 bar (abs).
    c) Opening test at 140ºC (5 series) ambient / 4,76 bar (abs).
    d) Opening tests at different pressures / temperatures.

4. Accelerated aging process (> 15h @ 120ºC)

5. Functional tests in DBA accident conditions.
    a) Start of environmental qualification test (4 days)
    b) Previous opening tests at 120º and atmosphere at 2,00 bar (abs).
    c) Post DBA opening Test at 120º and atmosphere at 2,00 bar (abs).

6. Functional test post DBA at ambient temperature / pressure.

7. Final post DBA valve inspection.

8. Seismic calculations.

The table of correspondence between the different tests and the test procedures is indicated below.

		Test procedures			
TIPE	**TEST**	**IN8-3-696 Overpres. & Leaks**	**IN8-3-697 Opening test**	**IN8-3-698 Pistons test**	**IN8-3-699 Environmental Qualif.**
FUNCTIONAL	Opening test (ambient)		X		
	Opening test (1bar @ 40 ºC)		X		
	Opening test (1bar @ 100 ºC)		X		
	Opening test (1bar @ 140 ºC)		X		
	DBA Opening test (2 bar @ 120 ºC)		X		X
	Opening test (different pressures/temperatures)		X		
	Closing test			X	
	Opening test			X	
SPECIFICATIONS	Leaking test	X			
	Overpressure test	X			
	Opening range test		X		
	Minimum opening pressure test			X	
	Minimum closing pressure test			X	
	Environmental Qualification test				X
QUALIFICATION	QV-7660 Functional. (ASME cap. III, NC)	X	X	X	
	QV-7620 environmental. (appendix QR-B)				X
	QV-6300 Leaks. (ISO 5208)	X			
	QV-7650 Seismic. (appendix QR-A)	N/A (calculated)			

5.6.1 Test procedures.

Six Test Procedures have been written to cover the total of tests necessary for the ASVAD valve functional verification. These test procedures are the following:

5.6.1.1 Testing plan IN8-3-695.

This procedure is a summary of the testing process to be performed on the valve:

- It includes a Log of the tests development and their incidents, if there were any.
- It includes a summary of compliance with the specifications for each procedure carried out.

5.6.1.2 Overpressure and leaks test IN8-3-696.

This test aims to demonstrate:

- The valve robustness against accidental overpressures.
- The compliance with specifications regarding maximum allowed leaks.

It partially fulfills the specifications requirements according to ASME chapter III, NC QV-6300 [14], and the ISO 5208-2008 [12] for the leakage section.

The acceptance criteria for this test are the following:

- OVERPRESSURE. With the valve lower chamber pressurized to 150% PN, no pressure leaks are observed in the valve for 10 minutes.
- LEAKS. With the valve lower chamber pressurized to 110% PD, no pressure leaks are observed in the valve obturator for 10 minutes.

5.6.1.3 Trigger point test IN8-3-697.

This test aims to demonstrate:

- The valve repeatability in its opening point. Its compliance with the maximum specified dispersion.
- The valve compliance with specifications regarding the permissible drift of the opening point with the temperature.
- Its compliance with the specifications regarding the opening point range of adjustment.
- Additionally, the accelerated aging process for the EPDM gaskets is carried out within this procedure.
- The ability to adjust it within the specified range.

It partially fulfills the functional requirements according to (ASME chapter III, NC).

The acceptance criteria for this test are the following:

- MIN SETTING RANGE. With the valve set to its lower value, the opening occurs at a value less than or equal to that specified.
- MAX ADJUSTMENT RANGE. With the valve set to its highest value, the opening occurs at a value greater than or equal to that specified.

- DISPERSION OF THE OPENING POINT. With the valve adjusted to 50% of its adjustment range (approx.), its opening occurs with a maximum dispersion of ± 1% PN over the average value of the valve opening point.
- OPENING POINT VS TEMPERATURE. The obtained drift percentage ratio with temperature (RPDT) is less than or equal to that specified.
- OPENING UNDER ACCIDENT CONDITIONS. With the valve subjected to the pressure and temperature conditions expected in an accident, it opens at a value that does not deviate more than ± 1 bar from the expected value of pressure for these conditions.
- ACCELERATED AGING PHASE. The valve has been subjected to 120 °C ± 5 °C (248 ºF ± 9 ºF) for at least 15 hours.

5.6.1.4 Pistons test IN8-3-698.

This test aims to demonstrate the piston functionality (opening and closing) in all the valve functional circumstances.

It partially fulfills the functional requirements according to (ASME chapter III, NC).

The acceptance criteria for this test are the following:

- CLOSING PISTONS. With the spring adjusted to its maximum strain, the valve in the open position, and its lower chamber depressurized, the minimum pressure required for closing (PMC) is less than or equal to the minimum specified.
- CLOSING PISTONS. The closing piston chamber is able to withstand and maintain the tightness at the maximum specified pressure for 10 minutes.
- OPENING PISTONS. With the spring adjusted to its minimum strain, the valve in closed position and its lower chamber at a pressure 110% PN, the minimum pressure required for opening (PMA) is less than or equal to the minimum specified.
- OPENING PISTONS. The opening piston chamber is able to withstand and maintain the tightness at the maximum specified pressure for 10 minutes.

5.6.1.5 Environmental qualification IN8-3-699.

This test aims to demonstrate the valve functionality during and after being subjected to the DBA environmental conditions (ambient pressure and temperature).

It complies with the specifications requirements according to (ASME appendix QR-A and IEE-323-1974 [15]).

The acceptance criteria for this test are the following:

- DBA OPENING. After 96 h in DBA environmental conditions and during this condition, the valve opens at the pressure (± 1% PN) expected for those circumstances.
- POST-DBA OPENING. After the DBA environmental conditions, the valve opens at the same pressure (± 1% PN) for the same circumstances.

5.6.1.6 Visual Inspection test IN8-3-700.

This test aims to demonstrate the visual valve state before and after being subjected to the environmental conditions of DBA (ambient pressure and temperature).

There are no specific acceptance criteria. This is left to the inspector's judgment.

5.7 RESULTS.

The carried out tests results are included in Annex V. From the analysis of them, it can be deduced that the tested prototype has satisfactorily covered all the criteria specified.

SUMMARY RESULTS		**Testing parameters**			
TYPE	**TEST**	**Proced.**	**Especified Value**	**Obtained Value**	**¿Fulfills?**
FUNCTIONAL	Ambient opening	IN8-3-697	n/a	17,49 bar	YES
	Opening (@ 3 bar(a) 100 ºC)	IN8-3-697	19,2 bar	19,20 bar	YES
	Opening (@ 4,8 bar(a) 140 ºC)	IN8-3-697	20,8 bar	20,65 bar	YES
	Valve opening point dispersion.	IN8-3-697	1% PN = 0,5 bar	0,2% PN = 0,1 bar	YES
	Temperature drift ratio (RDT)	IN8-3-697	≤ -0,025 Bar / ºC	≤ -0,005 Bar / ºC	YES
	Opening minimal pressure	IN8-3-697	≤ 13,1 bar	12,38 bar	YES
	Opening maximal pressure	IN8-3-697	≥ 19 bar	22,62 bar	YES
	Closing piston ability	IN8-3-697	closes	closes	YES
	Opening piston ability	IN8-3-697	opens	opens	YES
SPECIFICATIONS	Maximum leak observed @ 110% PD= 17,6 bar	IN8-3-696	No leak	No leak	YES
	Maximum leak observed @ 100% PN= 50 bar	IN8-3-696	No leak	No leak	YES
	Maximum leak observed @ 150% PN= 75 bar	IN8-3-696	No leak	No leak	YES
	Initial leak pressure point	IN8-3-696	1 bar > PD	1 bar	YES
	Opening minimal pressure	IN8-3-698	4 bar	2,90 bar	YES
	Closing minimal pressure	IN8-3-698	4 bar	3,54 bar	YES
	Opening maximal pressure	IN8-3-698	15 bar	15 bar	YES
	Closing maximal pressure	IN8-3-698	15 bar	15 bar	YES
	Aging time	IN8-3-697	>14,1 h	15 h	YES
QUALIFICATION	Pre-DBA opening @ 2,06 bar(a) / 120 ºC	IN8-3-699	n/a	17,58 bar	YES
	Post-DBA opening @ 2,06 bar(a) / 120 ºC	IN8-3-699	n/a	17,37 bar	YES
	Post-DBA opening @ Pamb / Tamb	IN8-3-699	n/a	16,9 bar	YES
	Post-DBA valve integrity	IN8-3-700	No damages	No damages	YES

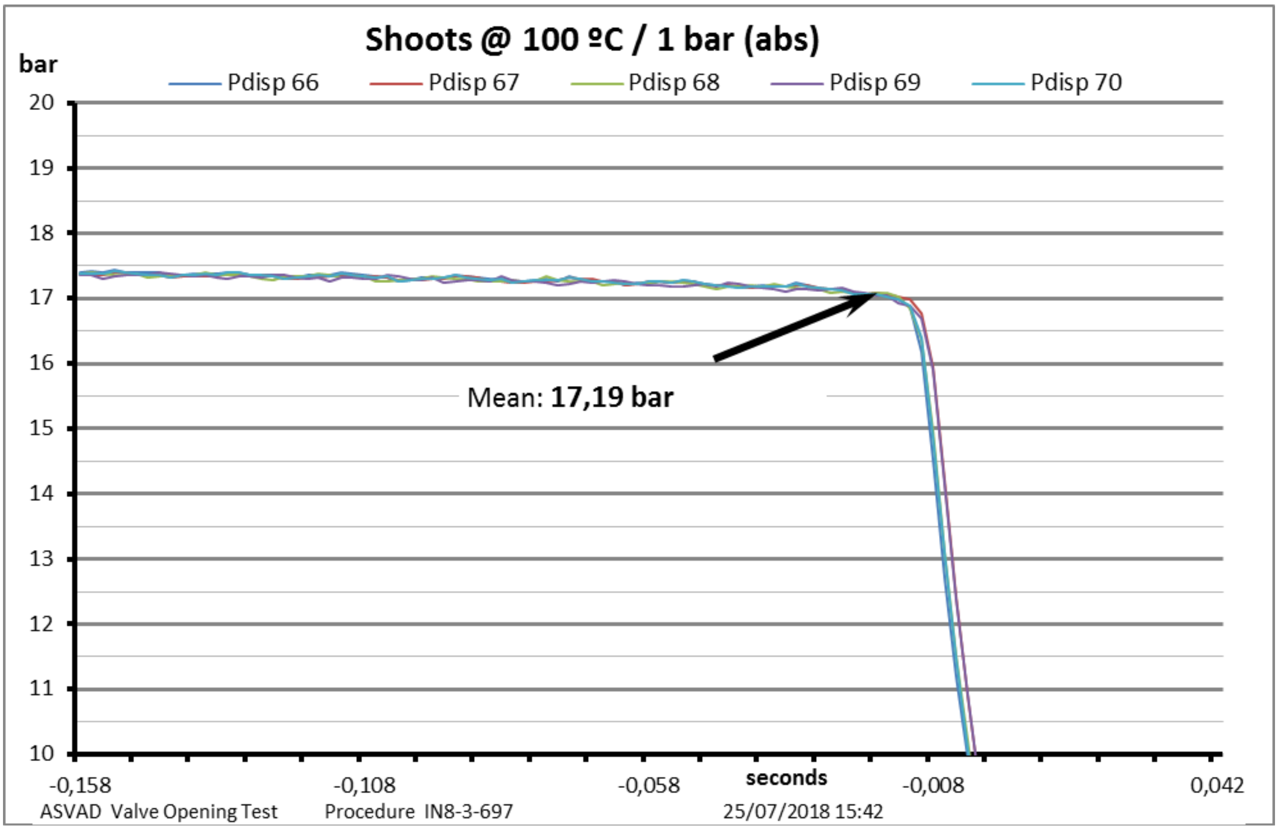
5.7.1 Opening test results (shoots).

The functional tests carried out with the procedure IN8-3-697 covers all the temperatures and pressures range during normal operation and DBA accident. 5 shots series were made at different temperatures and external pressures to know the effect from both variables over the valve trigger pressure.

The valve was adjusted around its midpoint for all the tests, except for the minimum and the maximum range tests in which the adjustment was carried from one side to the other. All shots were made by arming and pressurizing the pressure chamber with a pressure of 4 to 6 bar (57- 86 psi) pressurizing above the expected opening point. Under these conditions, a small leakage was caused that slowly lowered the pressure in the chamber until the moment when the valve opening occurred.

Given the quick valve depressurization, the shot exact pressure was obtained by a fast-response electronic pressure transmitter. The pressure evolution was processed in a high speed recorder with a 2 msec resolution. As example, one obtained pressure graph is shown in the figure. In it, the 5 shots of the series are superimposed in the last 0,2 seconds before the shot.

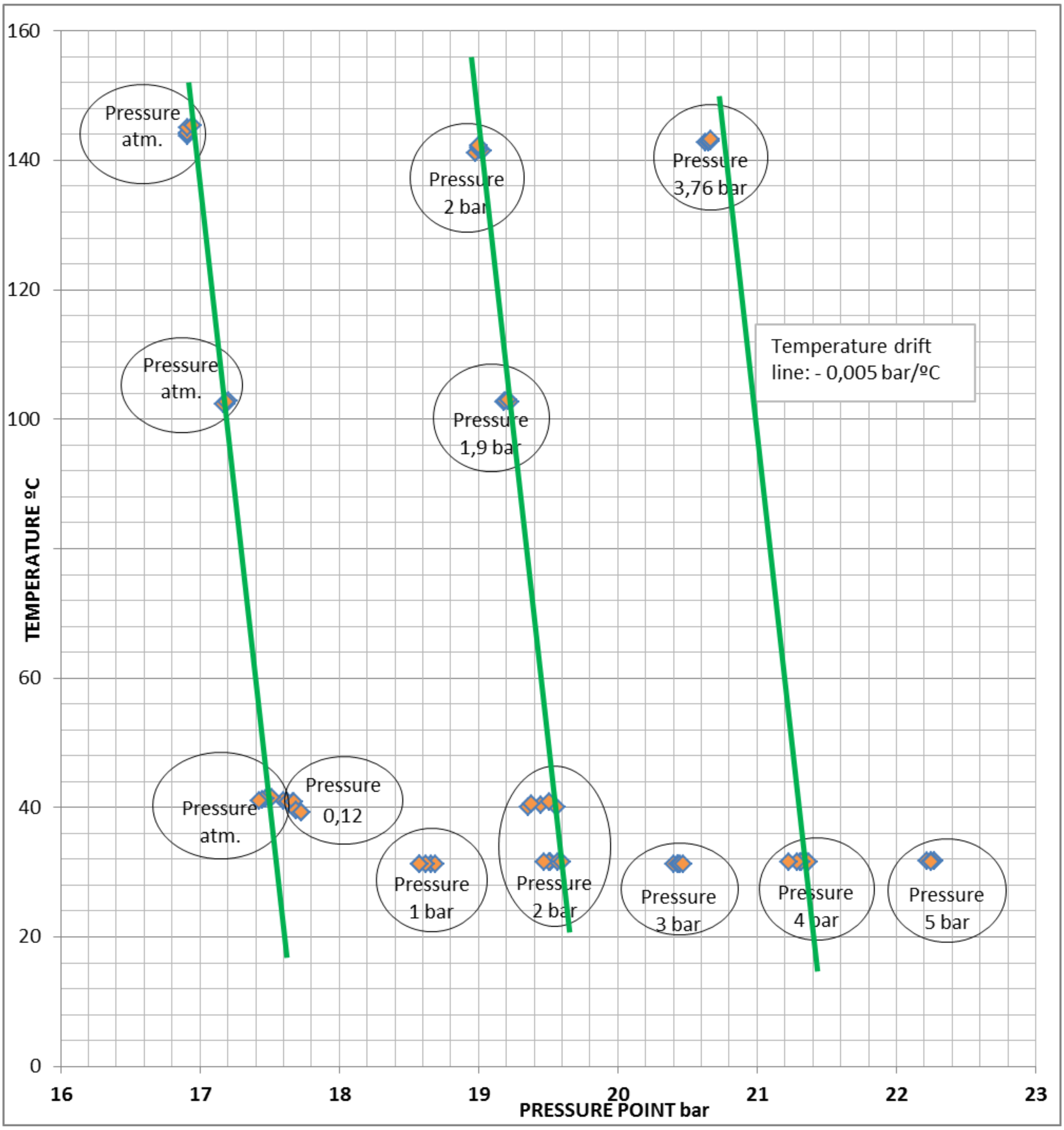
Series of 5 shots were made to obtain the actual valve opening point with enough statistics, and also to know the uncertainty and the opening values dispersion.



It is easily observed that all the valve shots happen practically at the same pressure with a minimum dispersion. In the case shown, the dispersion was just ±0,04 bar (<0,1% PN) (0,5 psi).

The following figure summarizes the series of shots made at different temperatures and pressures. Seeing the graph, it is easily known the temperature effect over the pressure point. It gave a small value of -0,005 bar/°C (-0,04psi/ºF) in the working range of 40 °C to 140 °C (104-284 ºF). These are the green lines.

The influence of the ambient pressure can also be seen, and it is greater and closer to 1. From the results obtained it can be deduced that a rise of 1 bar (14 psi) in the external pressure is practically translated into the same rise in the opening pressure. This is consistent with the effective surfaces ratio in the obturator during the shooting.

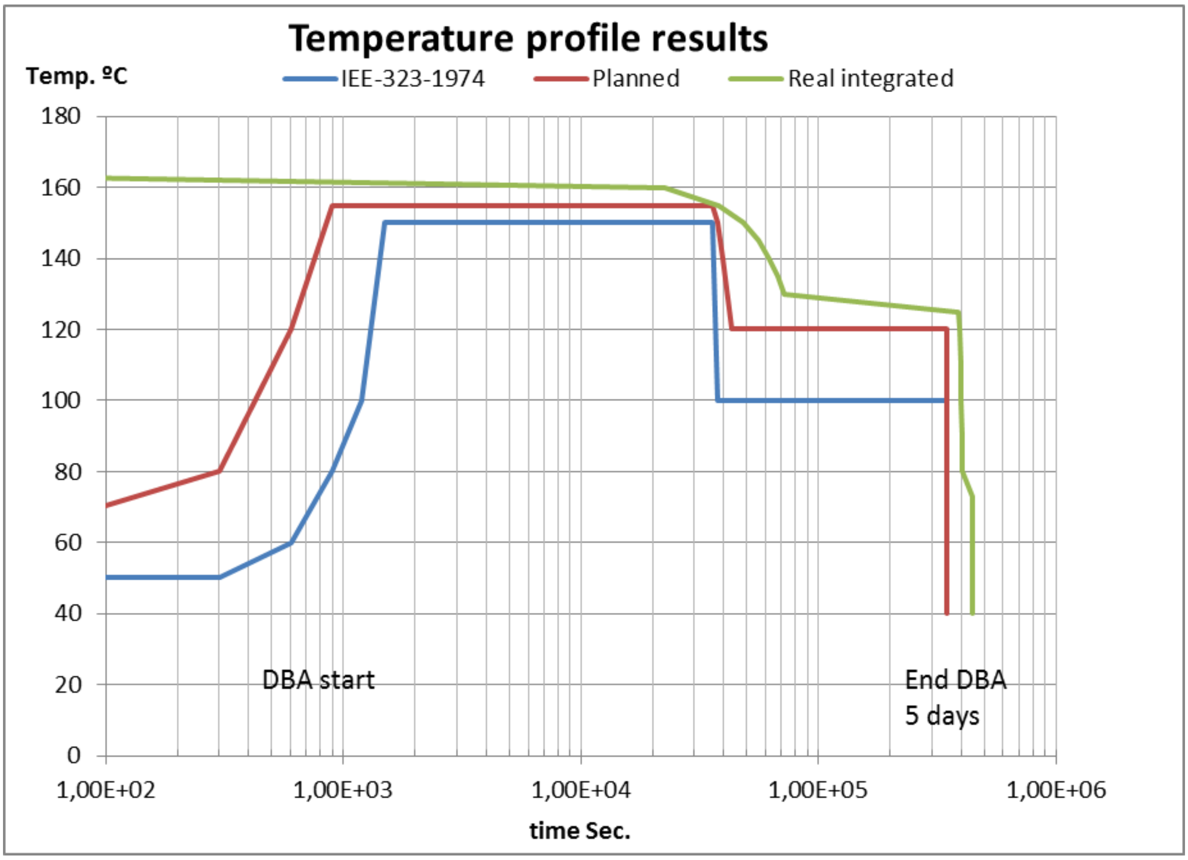


5.7.2 Environmental Qualification Results (Temperature).

The functional tests performed with the procedures IN8-3-697 and IN8-3-698 covers the normal operating temperatures and the DBA accident range. The IN8-3-699 test combines temperature and ambient pressure, simulating a large LOCA or HELB accident. The duration of the IN8-3-699 test gives full coverage to these accidents.

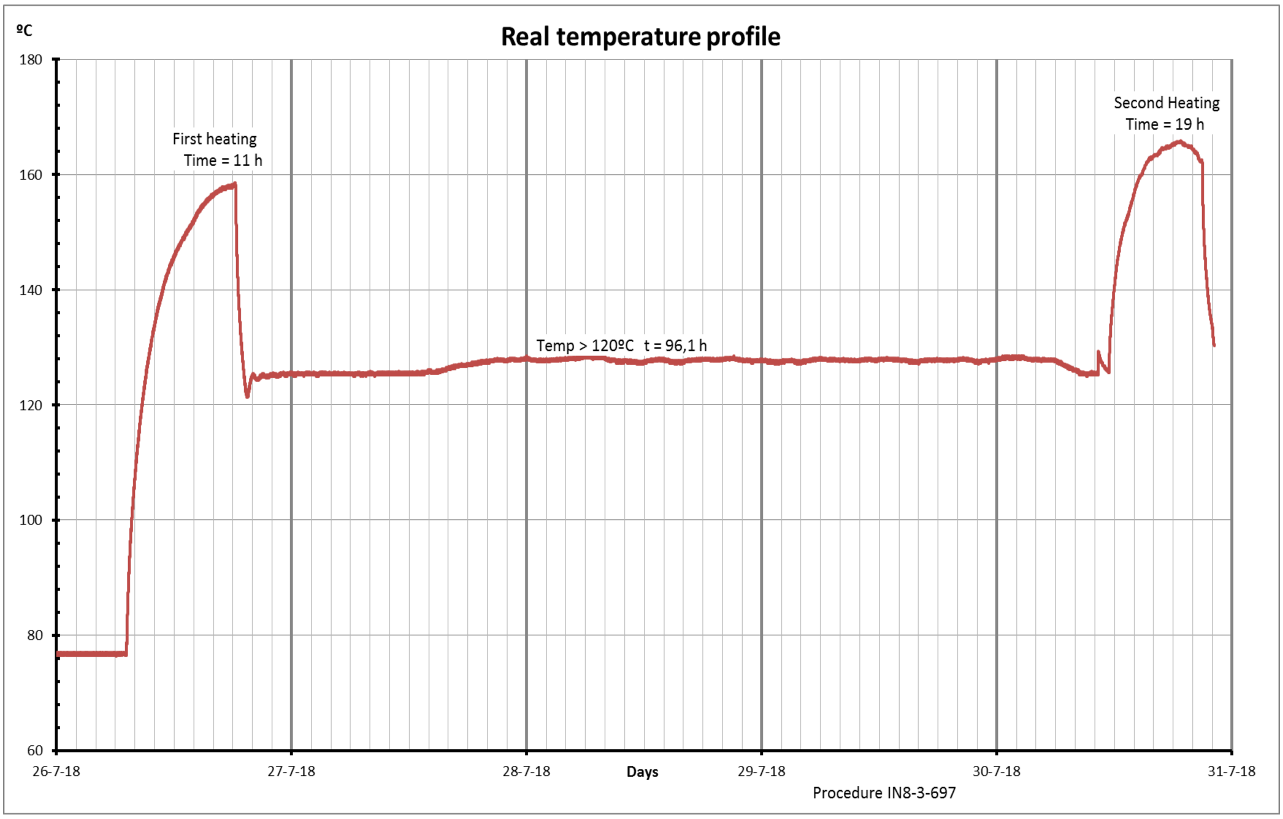
During the qualification tests, there were problems in the first heating phase. The required number of hours (10h) at 160ºC was not initially reached. This fact was known at the end of the 4th day test period, so it was decided to include a new additional heating phase at the end of the test, on this occasion the required times were achieved.

We consider that this change in the heating profile does not alter the test, since the heating integrated times to which the valve has been subjected, far exceed those established in the test specifications. In the graph, the times and temperatures to which the valve has been subjected during the qualification test are indicated in green.



It can be easily verified that the profile indicated in the specification IEE-323-1974 has been covered [15]. A summary of the results is as follows:

- Maximum temperature reached: **165ºC**
- Time above 160ºC (320ºF): **6,25 h**
- Time above 155ºC: (311ºF): **10,5 h**
- Time above 150ºC: (302ºF): **13,4 h**
- Time between 150ºC and 120ºC: **96,1 h** **4d** (302ºF – 248ºF)
- Time between 120ºC and 100ºC: **1,5 h** (248ºF – 212ºF)
- Total test time: **124 h** **5d 4h**



The test result shows that the valve is capable of withstanding the expected temperature conditions in the containment building for more than 124 hours. After this time, its functionality is demonstrated causing its opening action and checking that it does it approximately at the expected point.

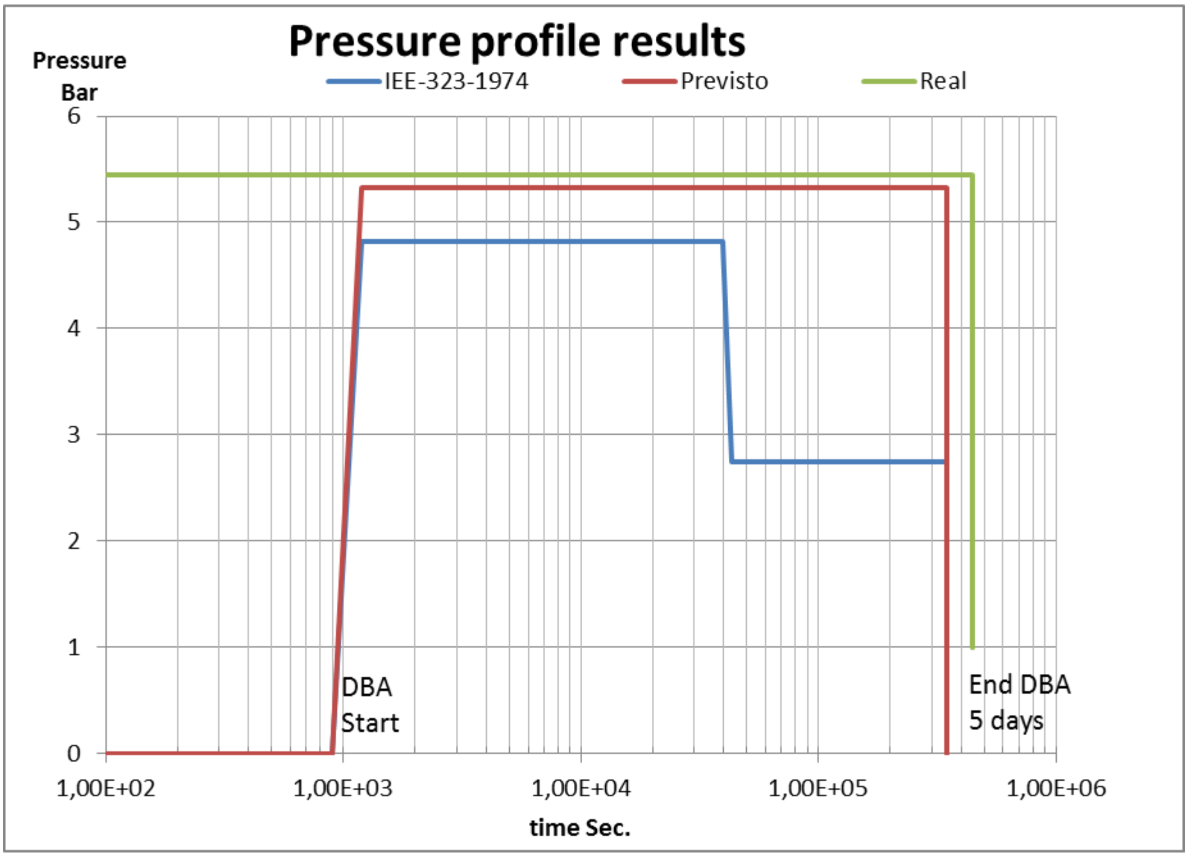
5.7.3 Environmental Qualification Results (Pressure).

The functional test carried out with the procedure IN8-3-699 covers the range of ambient pressures from normal operation to DBA accident.

During the valve qualification tests, the ambient pressure was maintained throughout all the time at a value greater than 5.4 bar (77 psi), and the pressure inside the valve was maintained at 110% PN (55 bar) (782 psi). It was only depressurized up to 1 bar (14 psi) at the end of the test and just before performing the post DBA opening.

It can be easily verified that the indicated profile in the specification IEE-323-1974 has been covered [15]. A summary of the results of the qualification tests is as follows:

- Maximum pressure reached: **5,5 bar** **(78 psi)**
- Time above 5.3 bar (75 psi): **124,2 h** **5d 4h.**



The first opening taken after the DBA test obtained a result of **17,39 bar** (247 psi), clearly similar to the previous openings that had thrown an average of 17,58 bar (250 psi). After the first, four more openings were made verifying that the valve also works properly in the closing function (no safety). The average of these 5 openings gave a value of 17,37 bar (247 psi) with a dispersion of only **0,03 bar** (0,4 psi) between them.

It is easy to deduce from these results that the ASVAD valve is very resistant to the effects of temperature, and practically insensitive to the pressure effects, which are already included in its operation.

5.7.4 Seismic Qualification.

The valve seismic qualification is made by calculation. These calculations are documented in annex IV.

From the results obtained, the ASVAD valve complies with all the specified requirements IEEE-344-2004 [7] and ASME III, div 1, subsection NC [11] & [14], and that it is able to withstand the effects of a seismic event SSE design without losing its capacity to carry out its intended safety function.

6 FAIL MODE ANALISIS

6.1 ASVAD valve generic FMEA.

In this section we develop a generic failure mode analysis of the ASVAD valve taken as a whole. From the analysis carried out, three different failure states can be determined, and additionally, a possible affectation in the valve opening point:

6.1.1 The valve fails open.

In this failure mode, the valve remains in the open position or with a similar functional effect. The final result of the failure will be the fully accumulator depressurization.

This failure mode can occur when the valve pressure chamber or its seal loses its structural integrity for some reason. Among the possible causes could be:

- The impact of high-energy projectiles that could break the pressure chamber. Extremely low probability of occurrence.
- Failures in the material integrity due to hidden defects, overexertion, overpressure, etc. Extremely low probability of occurrence.
- Failure in the remote opening system (when it is implanted) and / or the opening piston locked in its lower position after its accidental actuation. Very low probability of occurrence since it requires solenoid energization.

The way to discover this failure is the same as for the other system components: The monitoring system of the internal pressure in the accumulator and its corresponding low pressure alarms.

The contingency action to fix this kind of failures will be the isolation of the previous manual valve that isolates it from the accumulator. Once isolated, the normal accumulator pressure can be recovered by the existing systems. After that, valve maintenance can be carried out in situ or simply replacing the failed valve by another one.

The present failure mode **is similar** to failures due to breakage of any other element in the system subjected to its pressure, whether pipes, unions, valves, or instrumentation elements connected to the process. So they are already considered in the accumulator system Safety Study and **does not constitute a not evaluated new failure**.

1.1.1 Failure in closed position.

In this failure mode, the valve remains in the closed position or with a similar functional effect. The final result of the failure will be the non-evacuation of residual nitrogen when the circumstances for this occur.

This type of failure can occur for the following reasons:

- Breakage or main spring strength loss. Extremely low probability of occurrence given the robustness of it.
- Obturator mechanically locked in its closed position. Extremely low probability of occurrence given the available margin in the obturator.
- Failures in the material integrity due to hidden defects, overexertion, breakage of threads, etc. not related to the pressure chamber. Extremely low probability of occurrence.
- Failure in the closing remote system (when it is implemented) and / or the closing piston locked in its upper position after its actuation. Very low probability of occurrence since it requires solenoid energization.
- The isolation valve is forgotten in closed position. Low probability of occurrence.

During normal operation, this failure has no adverse effect on the system, since it is the valve's normal position. However, during the accident, the valve will not be able to perform its safety function. The obtained effect **is similar to the current situation** without the valve installed.

The way of discovering this failure is similar to that of some mechanical components of the system, such as other relief valves, and basically consists in their periodic functional test. Unlike this, the test can be done even during normal operation since there is the possibility to isolate the valve from the accumulator through the manual isolation valve.

By not presenting adverse effects during normal operation, contingency actions are not considered during this period. Once the problem has been discovered during the periodic tests, the contingency action will be the corrective valve maintenance. This can be done without disturbing the accumulator operation by isolating the previous manual valve. This allows the valve removal and its maintenance in the workshop.

This type of failure is similar to the system current state without the valve installed. Therefore, it is already considered in the safety study of the accumulator system and **does not constitute a not evaluated new failure**.

6.1.2 Not fully closed failure.

In this failure mode, the valve remains not fully closed, but neither open. This is when the valve presents a leakage through its seal that is not capable of causing its complete opening. The final result of this failure will be the gradual pressure loss in the accumulator until the moment when the valve opens due to said depressurization and completely empties the affected accumulator.

This type of failure can be caused by the same causes as the failure in the open position, but more specifically by problems in the main gasket, or the pressure chamber gasket. These causes could be:

- Mechanical or chemical gasket degradation. An extremely low probability of occurrence since the gaskets are completely boxed at all time and only work statically.
- Dirt or foreign elements presence in the seals. Very low probability of occurrence. Only due to a poor or defective maintenance that would be quickly discovered when pressurized.
- The fastening screws loosening at the main gasket combined with pressure forces. Extremely low probability of occurrence, because the gasket would still remains in its position by the obturator force.
- Failures in the material integrity due to hidden defects, overexertion, overpressure, effect of temperature, radiation, etc. Extremely low probability of occurrence.

The way to detect this failure is the same as for the failure in the open position: The accumulator pressure monitoring and the corresponding low pressure alarms. Although in this case, the ability to cope with this failure is facilitated by the slow evolution of the pressure drop, which will depend on the leakage flow.

The contingency action will be also the isolation valve closure. Once isolated, the normal accumulator pressure can be recovered by the existing systems. After that, the faulty valve can be replaced by another one.

This type of failure is similar to other failures due to breakage of any other element of the system that is subjected to the pressure of the same, whether pipes, unions, valves, or instrumentation elements, so they are already considered in the accumulator system safety study and does not constitute a not evaluated new failure.

1.1.2 Valve opening point uncertainties during the accident.

Although it can not really be considered as a failure, in this chapter, we analyze the deviations from the expected opening point due to the accident influence. In particular when the valve subjected to the accident conditions, opens outside its desired opening point. It can be called as the valve opening point uncertainty.

The impact of this uncertainty on the system will depend on whether the opening action takes place before or after the preset pressure point. If opens before, it will lead to losing the liquid volume that remains in that moment in the accumulator. If, on the contrary, it occurs with delay, it can allow the injection of a certain nitrogen quantity into the system until the valve opens.

The uncertainty may occur due to some derived causes from the accident, such as the following:

a) The spring mechanical strain decrease (relaxation) due to the heating effect derived by the temperature rise in containment. This can cause the valve to open at a pressure lower than specified.
b) The pressure and temperature rise in the containment and its effect on the obturator balance. This effect would cause the valve to open at higher pressure than specified, since this pressure helps the spring to open.

c) When the accumulator loses its initial pressure for other reasons than the injection itself. These reasons can be the overpressure relief valve opening, or pressure leaks in the accumulator system due to other components failures.
d) The valve exposure to accelerations in the Z axis greater than 6 g when the injection is in its final phase.
e) The drifts or uncertainties inherent of the valve. These uncertainties are the characteristics of the valve and do not necessarily have to be related to the accident.
f) The spring mechanical strain relaxation due to the combined effect of time and mechanical stress. The effect produced is similar to that from section a).

To minimize the effects of these incidents over the valve opening point, various compensatory measures have been implemented in the valve design. Those incidents that can not be compensated must be considered as basic uncertainties when choosing the optimum opening point.

The valve opening point determination must be carried out by end users, taking into account the special conditions of each installation and the valve specifications itself.

The implemented compensatory measures are the following:

1) In relation to the causes (a) and (b), a careful choice of the spring material and its metallurgic treatments to minimize its relaxation effects. The relaxation by time in service can be simply eliminated by thermal treatment of the spring. From the data obtained during the qualification tests, it is found that the relaxation by temperature is maintained below -0,01 Bar/ºC (-0,14 psi/ºF), and does not constitute an appreciable deviation.
2) In relation to cause (b), the containment pressure is already taken into account in the valve design to take advantage of its beneficial influence to compensate the pressure variation that happens in the accumulator itself. In fact, this influence is used to improve the response of the valve during an accident for the specified temperature range (50ºC to 130ºC) (122ºF to 266ºF).

For the remaining causes (c), (d), (e), and (f), there is no compensatory measure for the following reasons:

- For cause (c), and since they are due to causes completely unrelated to the ASVAD valve, they can not be considered in this study.
- For cause (d), given the extremely low probability of this circumstance, it will not be considered in this study either.
- The cause (e), is inherent to the valve, and can only be evaluated statistically by successive tests under homogeneous conditions. Although a maximum uncertainty of 1% of the PN (0,5 bar) (7 psi) has been determined in the specifications, the tests results have reduced this uncertainty to only 0,1 bar (1,4 psi).

The uncertainty in the accident conditions will have to be included in the engineering estimation of the valve opening point pressure. It is not convenient to include in these estimations the effect of the possible accelerations in Z axis produced by a SSE earthquake during the final injection phase, given that their probability of concurrence is extremely low.

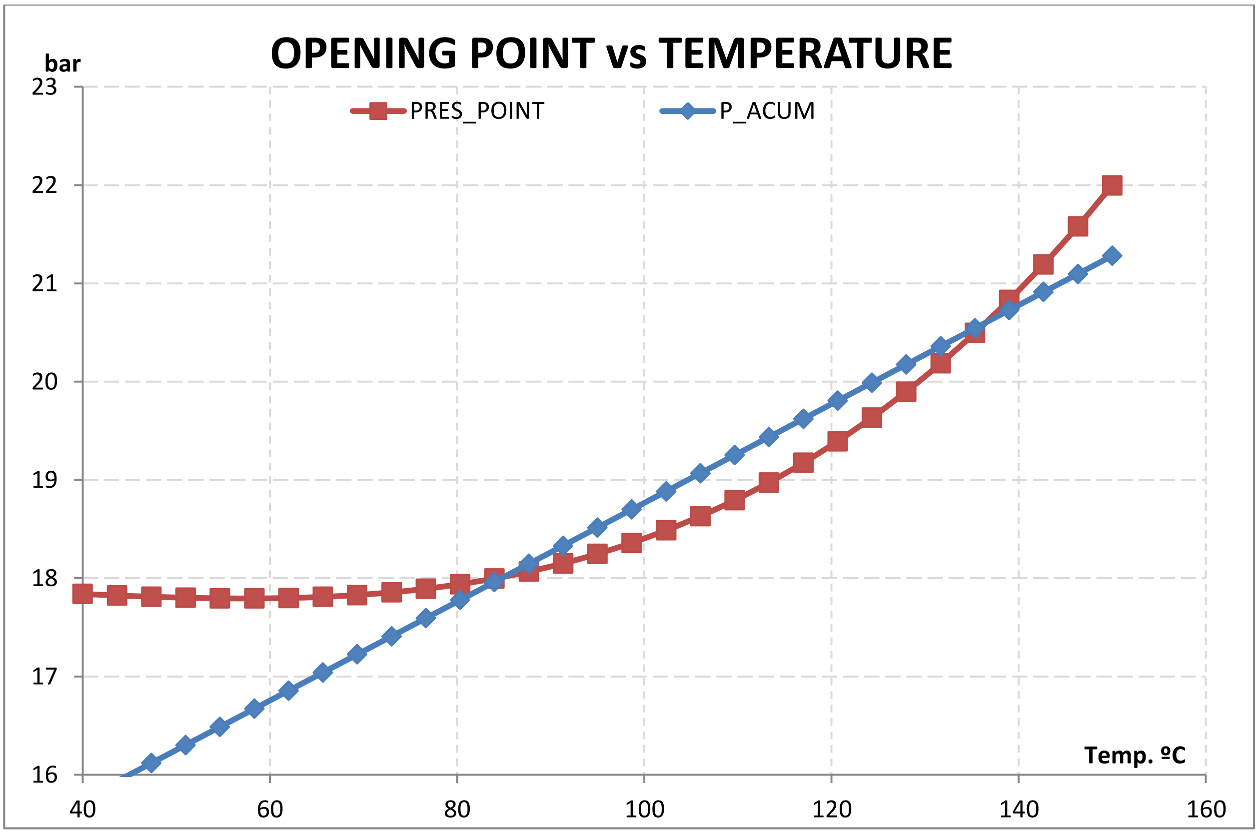
The estimation of the valve opening point pressure will be under the end user responsibility. It should be made based on the specific installation characteristics. The consideration of whether it is preferred, if the accumulator water injection should be completed as much as possible, despite allowing the injection of certain amount of nitrogen, or just on the contrary, letting some liquid volume remains in the accumulator to guarantee that no gas enters in the system.

Although the final results will depend on the specific parameters of each application, it has been estimated that an uncertainty of 0,5 bar (7 psi) in the valve opening point is equivalent to approximately 1,8% of the remaining level in the accumulator. This implies that despite the uncertainties, it can be considered that the valve will open when the accumulator is practically empty and after having completed its safety action.

As a final resume about the uncertainties in the valve opening point, it can be concluded that the simple installation of the ASVAD valve will always be beneficial for the accident mitigation, since even in the case of deviations from the ideal pressure point, **it will always go far beyond currently existing strategies.**

The installation of the ASVAD valve in the accumulator system **will always be favorable** compared to the current power plant conditions without its presence.

As an example, the following figure shows how the accumulators residual pressure and the valve opening pressure depending on the containment temperature evolve. The good correlation between both variables can be seen graphically during the temperature range considered in the accident (60ºC -140ºC). (140ºF -284ºF).



6.1.3 Degradation and aging mechanisms.

The ASVAD valve is almost entirely built with stainless steel A182 F316L. The only non-metallic components are the EPDM gaskets that constitute all the seals.

For this reason, the normal degradation mechanisms (temperature, humidity, radiation, vibrations, chemical attack...) will be considered only for the non-metallic components.

Other mechanical mechanisms such as wear by cycling, vibrations or earthquakes, can not constitute a degradation mechanism to be considered, given that:

- The valve is closed during all its normal operation, and only opens in accident conditions or during periodic functional tests.
- The valve is installed in the vicinity of the accumulators, which are usually areas not subjected to direct radiation, or near high energy lines. It is also not considered that it could be submerged, although this would not affect its operation either.
- The pipe that connects with the accumulator is not prone to transmit vibrations, since the accumulators are passive static systems.
- Given the internal constitution of the valve, the dynamic forces generated by the design earthquakes in the x and y planes do not have an impact on their function. The forces in the Z plane can influence the valve opening point only if they occur in coincidence with the final process of accumulators emptying, which is highly unlikely.

For all these reasons, it will be considered the temperature as the only degradation mechanism for the non-metallic components.

6.2 Fail mode analisis (FMEA) by component.

A detailed failure analysis is done to each valve component. This is presented together with its consequences in Annex VI. In this table the following columns are indicated:

1. Item number according to the shcema of Annex I.
2. Name of the Component.
3. Failure Mode.
4. Effect on the valve / system.
5. Fault detection mode.
6. Probability of occurrence.
7. Consequences

The summary of the same shows that the probability of occurrence of these failures for all the components is extremely low, since they are metal components and especially robust, even the gaskets that are the mechanically weakest components, being embedded in their holes, are well protected from mechanical stresses. In addition its operation is completely static, which results in its high reliability.

On the other hand, the adequate tolerances between the pieces and its high hardness drastically reduce the blockage possibilities in the pistons and in the obturator.

The ways to detect failures in the ASVAD valve components are summarized in three different ways:

1. Alarm due to accumulator depressurization.
2. The valve functional test.
3. Visual inspection.

The consequences of these failures in the ASVAD valve components are summarized in the three consequences indicated for the complete set, plus the non-consequence:

1. Accumulator depressurization (open failure).
2. Nitrogen not vented (closed failure).
3. Affectation in the valve opening point (by temperature or pressure).
4. No consequence.

6.3 Mean time between fails.

The mean time between failures in this valve type can be difficult to quantify given that it is a new element for which there is no statistical data yet.

However, it can be considered to be very similar to an overpressure relief valve. This can be easily argued given that the components in both valves are similar and they are made of the same materials. They also share the fact that during normal operation, they remain static and do not work.

Considering this, the average estimated time between failures for the ASVAD valve is > 20 years.

7 COMPLIANCE WITH REGULATORY STANDARDS.

7.1 DESIGN CRITERIA 10 CFR 50.10.

For the ASVAD valve validation and qualification, we have based on the NRC standards described in document 10 CFR 50 [3] [4], which provide adequate coverage to validate its use in practically all NPPs.

Many of these standards are not applicable to the ASVAD valve. Only those that may have some application on its design, use and operation will be described.

7.1.1 QUALITY SYSTEMS (GDC 1)

Section GDC 1 of Annex A 10 CFR 50 [3] describes the quality requirements necessary to maintain an adequate quality control:

“Structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. A quality assurance program shall be established and implemented to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions. Appropriate records of the design, fabrication, erection, and testing of structures, systems, and components important to safety shall be maintained by or under the control of the nuclear power unit licensee throughout the life of the unit.”

The ASVAD valve has been designed, manufactured, and tested under the Ringo Valves quality system and is described in the appendix references. This quality system ensures that the valve manufacture will meet the quality standards of its class. The validation tests carried out demonstrate its ability to meet the required specifications. These records will be maintained during the product useful life.

7.1.2 DESIGN BASES FOR NATURAL PHENOMENA (GDC 2).

Section GDC 2 of Annex A 10 CFR 50 [3] describes the design requirements that safety elements must comply with in relation to their protection from the natural phenomena:

“Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects

of the natural phenomena and (3) the importance of the safety functions to be performed."

The ASVAD valve has been qualified according to the earthquake criteria envelopes used in high seismicity power plants. In particular, the vertical acceleration considered is 6G, and the horizontal acceleration reaches 8.5G. The results guarantee that the valve will not lose its ability to operate properly even after an OBE earthquake. The effect of the vertical accelerations over the valve opening point has been considered, but given the very low possibility that the accumulator's final depressurization phase will concurs with an earthquake, that situation has been disregarded. Even in that case, it would be preferable to have the protection against the nitrogen injection.

7.1.3 FIRE PROTECCION (GDC 3)

Section GDC 3 of Annex A 10 CFR 50 [3] describes the design requirements that safety elements must comply with in relation to its protection against fire:

"Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Noncombustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety. Firefighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components."

Due to its metallic design, the ASVAD valve can neither cause fires nor propagate them. Being almost completely metallic, it is practically immune to it. For this reason, no specific tests have been planned for its demonstration.

7.1.4 ENVIRONMENTAL PROTECTION (GDC 4)

Section GDC 4 of Annex A 10 CFR 50 [3] describes the design requirements that safety elements must meet in relation to their ability to maintain its functionality during the adverse environmental conditions that occur after the postulated accidents, as well as providing sufficient resistance to the effects of possible missiles:

"Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit. However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping."

The ASVAD valve has been tested under the pressure and temperature envelope criteria estimated for a DBA accident in containment. The results guarantee that the valve will not lose its ability to operate even in the postulated DBA conditions. The humidity effect, or the water presence (even when completely submerged), does not impede its operation. Other environmental effects have been disregarded like the radiation effects, considering that the valve is immune to them.

In relation to the possible missiles produced by ruptures in high energy pipes, the ASVAD valve is unlikely to be affected by them, given its intrinsic robustness combined with its small volume and rounded shapes.

7.1.5 RCS PRESSURE BARRIER (GDC 14, 30 y 31)

Sections GDC 14 and 30 of Annex A 10 CFR 50 [3] describe the design requirements that the reactor coolant system must meet in relation to its ability to maintain the pressure barrier integrity.

“The reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.”

“Components which are part of the reactor coolant pressure boundary shall be designed, fabricated, erected, and tested to the highest quality standards practical. Means shall be provided for detecting and, to the extent practical, identifying the location of the source of reactor coolant leakage.”

“The reactor coolant pressure boundary shall be designed with sufficient margin to assure that when stressed under operating, maintenance, testing, and postulated accident conditions (1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The design shall reflect consideration of service temperatures and other conditions of the boundary material under operating, maintenance, testing, and postulated accident conditions and the uncertainties in determining (1) material properties, (2) the effects of irradiation on material properties, (3) residual, steady state and transient stresses, and (4) size of flaws.”

Although these criteria do not apply to the valve as they do not belong to the RCS pressure barrier, the ASVAD valve has been designed under the same pressure resistance criteria than the accumulators system where it will be installed. The results of the leakage and overpressure tests can guarantee its pressure barrier integrity even in the postulated DBA conditions.

7.1.6 SAFETY PROTECTION SYSTEM (GDC 20)

Section GDC 20 of Annex A 10 CFR 50 [3] describes the design requirements that Automatic Protection Systems must meet.

“The protection system shall be designed (1) to initiate automatically the operation of appropriate systems including the reactivity control systems, to assure that specified acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences and (2) to sense accident conditions and to initiate the operation of systems and components important to safety.”

Although this section does not specifically apply to the ASVAD valve, it is included here only to show that the valve, due to its special design, is capable of automatically starting its safety function. The tests of this automatic function have been described in section 5.6.1.3.

7.1.7 RELIABILITY AND TESTEABILITY (GDC 21)

Section GDC 21 of Annex A 10 CFR 50 [3] describes the design requirements that the Automatic Protection Systems must comply with in relation to the reliability and its testing capabilities.

“The protection system shall be designed for high functional reliability and in service testability commensurate with the safety functions to be performed. Redundancy and independence designed into the protection system shall be sufficient to assure that (1) no single failure results in loss of the protection function and (2) removal from service of any component or channel does not result in loss of the required minimum redundancy unless the acceptable reliability of operation of the protection system can be otherwise demonstrated. The protection system shall be designed to permit periodic testing of its functioning when the reactor is in operation, including a capability to test channels independently to determine failures and losses of redundancy that may have occurred.”

The ASVAD valve has been designed under the simplicity and efficiency criteria in its components. The low number of them, its simplicity and robustness, as well as the physical principles on which its operation is based can guarantee a high reliability. The low failure probability, together with the low probability of being required to actuate during the life of the plant, allow to discard the need for redundancies, although its implementation would not be a problem either.

In relation to the ASVAD valve testability, its installation after a manual isolation valve allows its maintenance or testing even under normal operating conditions and without negatively impacting the accumulator operability. Given its high reliability, its maintenance and testing can be done between long operation periods and during the plant shutdown.

The design simplicity of its components and the easy assembly between them, allows easy maintenance by the simple visual inspections of its internal components. All its surfaces are easily inspectable.

7.1.8 PROTECTION SYSTEMS INDEPENDENCE (GDC 22).

Section GDC 22 of Annex A 10 CFR 50 [3] describes the design requirements that Automatic Protection Systems must meet in relation to their independence from other systems.

"The protection system shall be designed to assure that the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels do not result in loss of the protection function, or shall be demonstrated to be acceptable on some other defined basis. Design techniques, such as functional diversity or diversity in component design and principles of operation, shall be used to the extent practical to prevent loss of the protection function."

Although this section does not specifically apply to the ASVAD valve, it is included here only to show that the valve is completely independent from any other system. It only depends on the accumulator pressure, which is the variable monitored by the valve.

7.1.9 PROTECTION SYSTEMS FAULT MODES (GDC 23).

Section GDC 23 of Annex A 10 CFR 50 [3] describes the design requirements that the Automatic Protection Systems must comply with in relation to their failure mode.

"The protection system shall be designed to fail into a safe state or into a state demonstrated to be acceptable on some other defined basis if conditions such as disconnection of the system, loss of energy (e.g., electric power, instrument air), or postulated adverse environments (e.g., extreme heat or cold, fire, pressure, steam, water, and radiation) are experienced."

The ASVAD valve failure modes have been described extensively in section 6. All these failures have been previously considered for other elements of the accumulator system.

The physical principles that govern its operation lead in most failure cases to a safe position (closed). Those other failures that lead to the accumulator depressurization, despite putting the system to an unsafe condition, are quickly detectable and correctable by the operators.

7.1.10 PROTECTION AGAINST OPERATIONAL EVENTS (GDC 29).

Section GDC 29 of Annex A 10 CFR 50 [3] describes the design requirements that the Automatic Protection Systems must comply with in relation to the operation thereof, whether normal or erroneous.

"The protection and reactivity control systems shall be designed to assure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences."

Although this section does not specifically apply to the ASVAD valve, it is included here only to show that the valve is completely independent from the normal operation of the system. The valve remains closed at all times while the accumulator is operable.

Only when the accumulator pressure is low enough (and therefore the accumulator is already inoperable) the valve is capable to act. The consequences from the valve erroneous operation (manual opening or closing), is not different from the erroneous operation on other components in the system. The worst operational error (remote opening) can only lead to the accumulator loss of pressure, but it can be easily detected and corrected.

7.1.11 CONTAINMENT ATMOSPHERE CONTROL (GDC 41).

Section GDC 41 of Annex A 10 CFR 50 [3] describes the design requirements that the Control or management systems in the containment building must comply with in relation to their integrity.

"Systems to control fission products, hydrogen, oxygen, and other substances which may be released into the reactor containment shall be provided as necessary to reduce, consistent with the functioning of other associated systems, the concentration and quality of fission products released to the environment following postulated accidents, and to control the concentration of hydrogen or oxygen and other substances in the containment atmosphere following postulated accidents to assure that containment integrity is maintained.

Each system shall have suitable redundancy in components and features, and suitable interconnections, leak detection, isolation, and containment capabilities to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) its safety function can be accomplished, assuming a single failure.."

Although this section does not apply directly to the ASVAD valve, it is included here to show that the valve operation releasing the nitrogen from the accumulators to the containment atmosphere does not cause any additional risk to the containment integrity different from the inevitable pressure rise.

This pressure rise must be considered explicitly for each particular case taking into account the amount of gas present in the accumulators, and the total volume of the containment among other factors. In general, this increase is within the containment operational limits and does not represent an immediate risk. On the other hand, the released nitrogen from the accumulators has two additional effects helping to maintain its integrity:

- The containment atmosphere inertization, by increasing the amount of nitrogen present in it.
- The cooling produced by the released nitrogen expansion.
- It can also help in some specific situations when the containment pressure is below the atmospheric pressure.

7.2 VENTING SYSTEMS.

Section 46a of Annex A 10 CFR 50 [1] describes the design requirements that RCS Venting Systems must meet.

“Each nuclear power reactor must be provided with high point vents for the reactor coolant system, for the reactor vessel head, and for other systems required to maintain adequate core cooling if the accumulation of noncondensible gases would cause the loss of function of these systems. High point vents are not required for the tubes in U-tube steam generators. Acceptable venting systems must meet the following criteria:
(a) The high point vents must be remotely operated from the control room.
(b) The design of the vents and associated controls, instruments and power sources must conform to appendix A and appendix B of this part.
(c) The vent system must be designed to ensure that:
(1) The vents will perform their safety functions; and
(2) There would not be inadvertent or irreversible actuation of a vent.

This section does not apply directly to the ASVAD valve, since the venting performed is not over the RCS but over the accumulators. However, it is included here to show that the ASVAD valve also meets these criteria when using the remote pilot option. In fact, the main function of the valve is to vent these incondensable gases outside the RCS

7.3 FULLFILMENT TO 10 CFR 50.59.

The 10 CFR 50.59 standards [2] describes the requirements and precautions necessary to carry out design changes in safety ESCs,

The ASVAD valve installation in the accumulator system will imply some changes in the Final Safety Study, as well as in the normal operating procedures and/or the failure procedures. It will also affect the emergency procedures, although its greatest impact will be the relaxation or avoidance in the current actions to avoid the nitrogen injection.

It will be the end user responsibility to adapt them to the new configuration. Other collateral impacts from the ASVAD valve installation, will be the modifications needed in the plant simulators, operators training, etc... All those changes are outside from this study because they are the end user responsibility.

8 CONCLUSIONS

Although it is not the object of this study to demonstrate the derived complications from a nitrogen injection to the reactor cooling systems, it can be concluded with certainty that such complications will always be detrimental to the reactor cooling. For this reason, the nitrogen injection from the accumulators **should ALWAYS be avoided**.

Nor is the subject of this study the detailed analysis of the current strategies to avoid such injection. However, it can be seen with a simple analysis of them, that all current strategies require the assistance of the following elements:

- A series of ACTIVE equipment for its execution.
- The efforts of the organization for its deployment and its control.
- And finally, these activities will depend on the accident evolution and can be considered critical over time.

The combination of these simultaneous needs can put under question the current strategies. Even if we can rely on them, they will always require a significant effort from the organization and without the whole safety of being able to achieve it.

The ASVAD valve **completely avoids all these problems**. Being a completely passive, unattended and automatic valve, it will discharge the organization to have to manage the nitrogen injection problem.

The ASVAD valve installation in the plants will be able to guarantee with a high level of confidence **that said injection will not occur**. In addition, this circumstance will allow the subsequent RCS depressurization to lower values, which may allow an easier and more efficient control of the accident recovery.

Summarizing:

If we ask ourselves the three main questions about the ASVAD valve, they would be:

1. Can the ASVAD valve be classified as nuclear class 2?

YES. The ASVAD Valve prototype has successfully completed the qualification tests described in section 5.7. On the basis of the tests successful completion, it is concluded that the ASVAD Valve has the documentation for its qualification as Nuclear Class 2, and it can be used without restrictions in the nuclear power plants for the automatic accumulators venting after its depressurization.

2. Can the ASVAD valve significantly decrease the operability of the system where it is installed?

NOT. For all the reasons explained mainly in section 6, the installation of the ASVAD valve in the accumulators does not add any failure mode other than those already analyzed. Being a passive element, its failure probability is similar to other structural elements of the system, such as the accumulator itself, its joints and pipes.

3. Can the ASVAD valve significantly increase the capacity to cope and mitigate accidents?

YES. For all the reasons explained above in section 3.5, the ASVAD valve installation in the accumulators significantly increase the organization capabilities to cope and mitigate accidents avoiding all those complications derived from its presence in the cooling systems.

But its installation not only has to be considered just adequate and feasible. Its installation <u>must be recommended or even imposed</u>. The needed inversion is very low compared with their help during the accident recovery.

For all the reasons previously indicated, we request a favorable assessment for its installation in the accumulators from the PWR nuclear power plants.

According to the international rules, the facilities are required to implement in their safety systems all those technical advances that are compatible with the existing design and improve the safety of the facilities.

For this reason, we also request that these guidelines will be enforced, and specific applicability studies will be requested from the power plants.

As a final summary of the entire document we will highlight these conclusions:

1. The nitrogen injection from the accumulators <u>should always be avoided.</u>
2. The plant current strategies <u>may not be efficient</u>.
3. The ASVAD valve <u>safely prevents</u> the nitrogen injection.
4. The ASVAD valve is nuclear class 2 and classified for its use in NPPs.
5. Its installation in the power plants <u>will substantially improve its safety</u> against the postulated accidents.

9 REFERENCED DOCUMENTATION.

1. **NRC regulations. 10 CFR 50.46a** Acceptance criteria for reactor coolant system venting systems.
2. **NRC regulations. 10 CFR 50.49** Environmental qualification of electric equipment important to safety for nuclear power plants.
3. **NRC regulations. 10 CFR 50. Appendix A.** General Design Criteria for Nuclear Power Plants**.**
4. **NRC regulations. 10 CFR 50. Appendix B.** Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.
5. **NRC REGULATORY GUIDE 1.100 1.1**. Revision 3. September 2009. Seismic qualification of electrical and active mechanical equipment and functional qualification of active mechanical equipment for nuclear power plants.
6. **ASME QME-1-2012**. Abril 2013. Qualification of Active Mechanical Equipment Used in Nuclear Facilities, endorsed by NRC [5].
7. **IEEE 344-2004**. junio 2005. IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.
8. **IEEE 323-1983**. IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Inc., 1983.
9. **EPRI NP-2129**. Radiation Effects on Organic Materials in Nuclear Pants:," Electric Power Research Institute, 1981. Page 3.24
10. **DOI: 10.5516/NET.2011.43.3.279**. A study on the aging degradation of Ethylene-propylene-diene monomer (EPDM) Under LOCA condition, Korea Institute of Machinery and Materials. 2011.
11. **ASME cap. III, NC.** 2015 Rules for the material, design, fabrication, examination, testing, overpressure relief, marking, stamping, and preparation of reports by the Certificate Holder of items which are intended to conform to the requirements for Class 2 construction.
12. **ISO 5208:2008.** Industrial valves. Pressure testing of metallic valves.
13. **NRC GENERIC LETTER GL-2008- 1**. ML072910759, January 2008. Managing gas accumulation in emergency Core cooling, decay heat removal, and Containment spray systems.
14. **ASME cap. III, Div.1 Subsection NC (Ed. 2007 addenda 2008).** Rules for construction of nuclear facility components. Division 1 - Subsection NC. Class 2 Components. Endorsed by NRC [5].
15. **IEEE 323-1974**. IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, Inc., 1974. Endorsed by NRC [5].

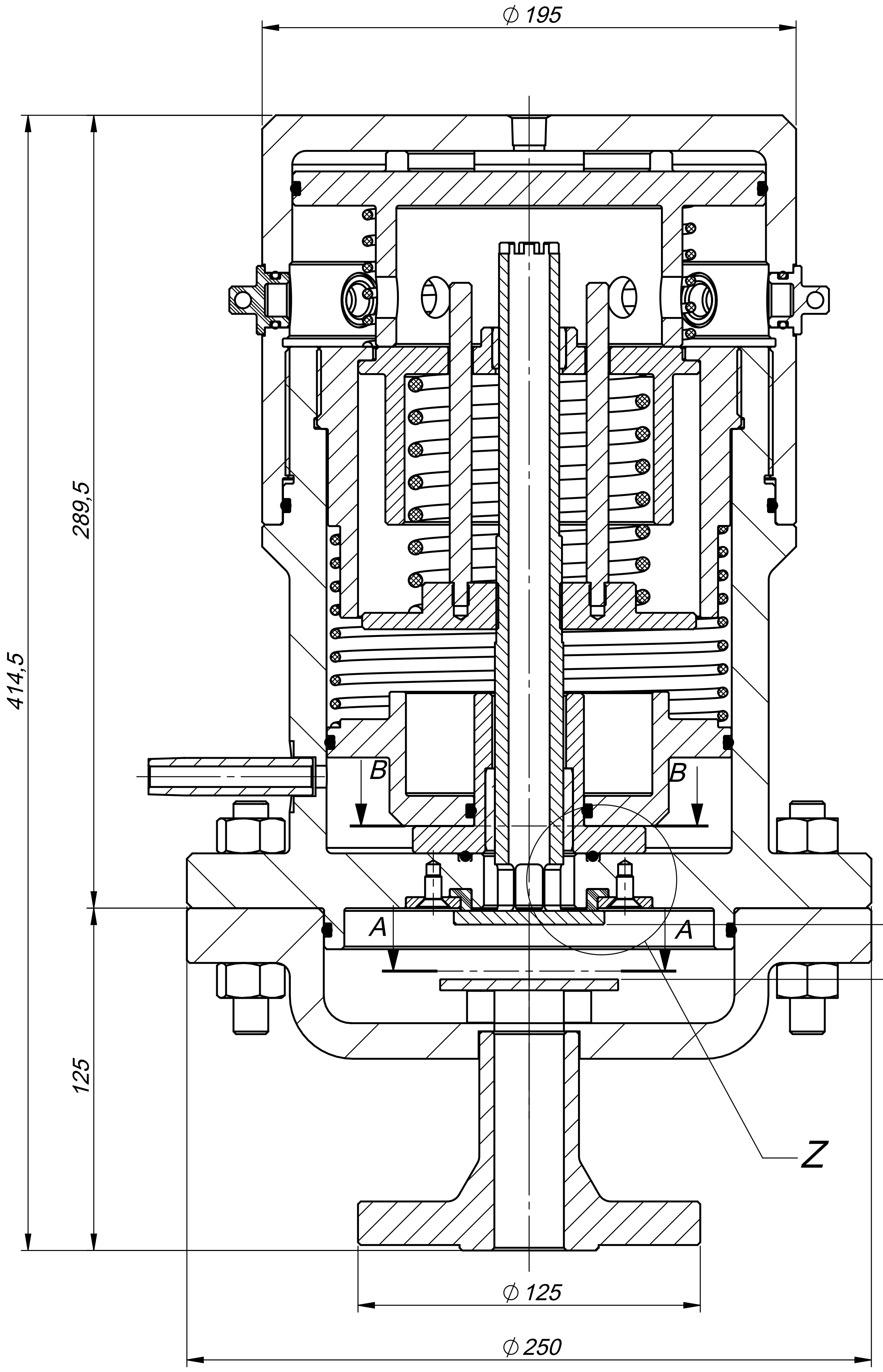
10 LIST OF ACRONIMS.

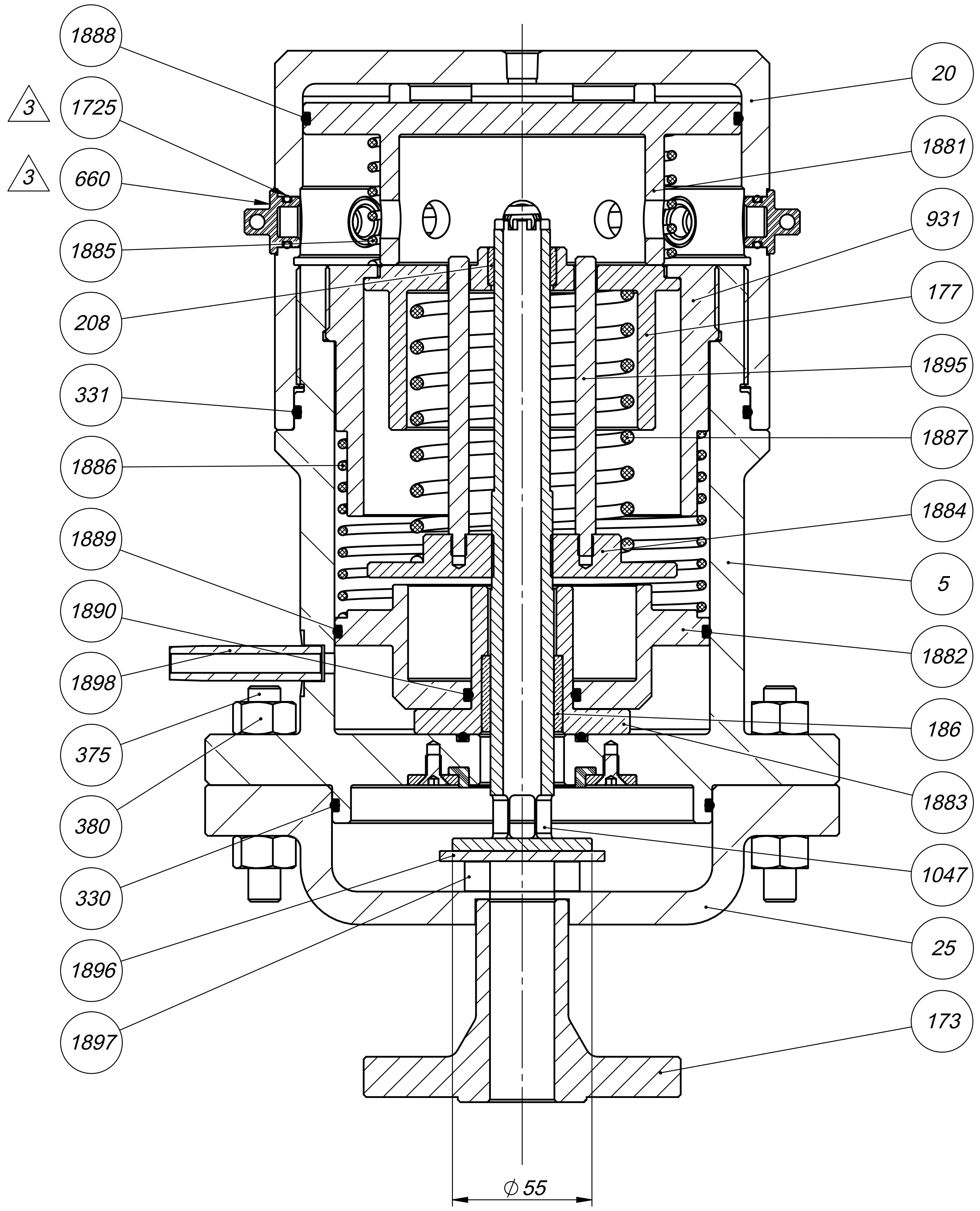
ASME	American Society Of Mechanical Engineers.
ASVAD	Automatic Safety Valve For Accumulator Depressurization.
CDF	Core Damage Frequency.
DBA	Design Basis Accident.
ELAP	Extended Loss Of AC Power.
EPDM	Ethylene Propylene Diene Type M.
EPRI	Electric Power Research Institute.
FLEX	Diverse And Flexible Coping Strategies.
FMEA	Failure Mode And Effects Analysis.
GMDE	Extended Damage Management Guides.
HELB	High Energy Line Break.
IEEE	Institute Of Electrical And Electronics Engineers.
ISO	International Organization For Standardization.
LOCA	Loss Of Coolant Accident.
LTSBO	Long Term Station Black-Out.
NRC	Nuclear Regulatory Commission (US).
NPP	Nuclear Power Plant.
OBE	Operating Base Earthquake.
PN	Nominal Pressure.
PSA	Probabilistic Safety Assessment.
PWR	Pressurized Water Reactor.
RCP	Reactor Coolant Pump.
RCS	Reactor Cooling System.
RPDT	Temperature Percentage Drift Ratio.
SG	Steam Generator.
SSC	Systems, Structures And Components.
SSE	Safe Shutdown Earthquake.

ANNEX I

ASVAD VALVE DIMENSIONAL SCHEMA

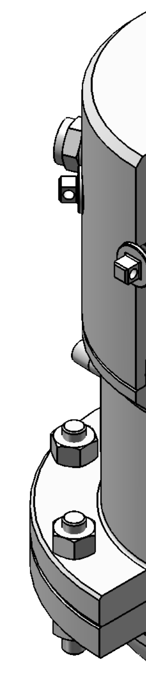
RV-E1306-3



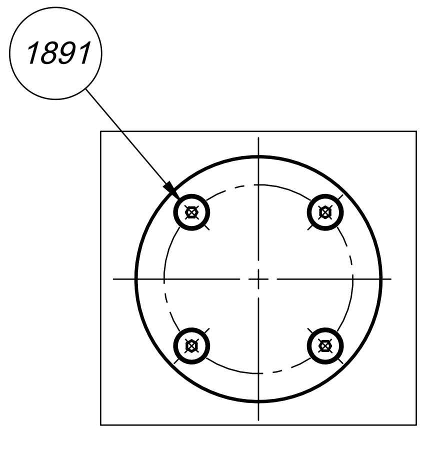


LISTA DE MATERIALES

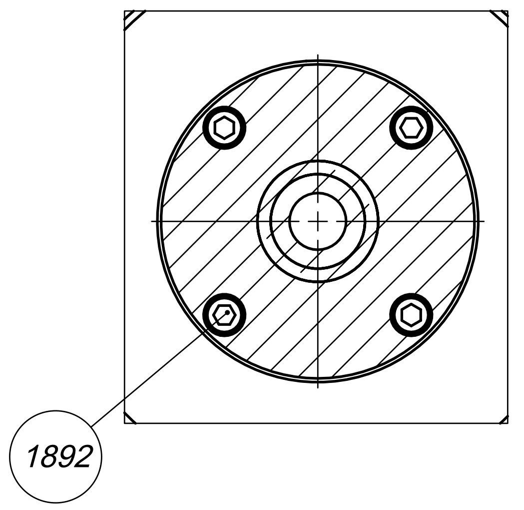
	POS.	CANT.	NOMBRE	REFERENCIA	MATERIAL
3	5	1	CUERPO	A3-009656-0	SA182 F316L (Niquelado)
	20	1	TAPA	A3-009657-3	A182 F316L (Niquelado)
3	25	1	TAPA INFERIOR	A3-009658-0	SA182 F316L
	70	1	ASIENTO	A4-009595-0	EPDM
3	173	1	BRIDA DE ENTRADA	A4-009589-0	SA182 F316L
	177	1	CAMISA PORTAMUELLES	A3-009662-0	A182 F316L
	186	1	CASQUILLO INFERIOR EJE	PSM 253230 A51	BRONCE
	208	1	CASQUILLO SUPERIOR EJE	PSM 222715 A51	BRONCE
	294	1	JUNTA TORICA CUERPO	2-224	EPDM
	330	1	JUNTA TORICA TAPA INFERIOR	2-255	EPDM
	331	1	JUNTA TORICA TAPA	2-261	EPDM
3	375	8	ESPARRAGO TAPA INFERIOR	ESPARRAGO 1-2 UNC X 110	SA453 GR660B
3	380	16	TUERCA ESPARRAGO TAPA INFERIOR	TUERCA 1-2 UNC	SA194 GR6 T410 (Bicromatado)
3	660	8	TAPON	A4-010602-0	AISI 316
	931	1	CILINDRO EQUILIBRADOR	A3-009664-0	A182 F316L (Niquelado)
3	1047	1	OBTURADOR PRINCIPAL	A3-009661-0	SA564 GR630 H1075
3	1725	8	JUNTA TÓRICA TAPÓN	2-114	EPDM
	1881	1	PISTON DE APERTURA	A3-009659-0	A182 F316L
	1882	1	PISTON DE CIERRE	A3-009660-0	A182 F316L
	1883	1	CILINDRO DE CIERRE	A4-009590-0	A182 F316L (Niquelado)
	1884	1	DISCO DE AJUSTE	A3-009663-0	A182 F316L
	1885	1	MUELLE APERTURA	A4-009872-0	F-143
	1886	1	MUELLE CIERRE	A4-009873-0	F-143
	1887	1	MUELLE REGULACION	A4-009874-0	F-143
	1888	1	JUNTA TORICA PISTON APERTURA	2-260	EPDM
	1889	1	JUNTA TORICA PISTON CIERRE EXTERIOR	2-254	EPDM
	1890	1	JUNTA TORICA PISTON CIERRE INTERIOR	5-321	EPDM
	1891	4	TORNILLO DEFLECTOR	TORNILLO M4X20 DIN7991	AISI 316
	1892	4	TORNILLO CILINDRO DE CIERRE	TORNILLO M6 DIN912 X15	AISI 316
	1893	4	TORNILLO PLACA PISADERA	TORNILLO M6 DIN7991 x 12	A453 GR660B
	1894	1	PLACA PISADERA	A4-009596-0	A182 F316L
	1895	2	GUIA ANTIGIRO	A4-009591-0	A564 GR630 H1075
	1896	1	DEFLECTOR	A4-009593-0	A182 F316L
	1897	4	TACO DEFLECTOR	A4-009592-0	A182 F316L
	1898	1	TUBO DE ENTRADA	A4-009594-0	A182 F316L



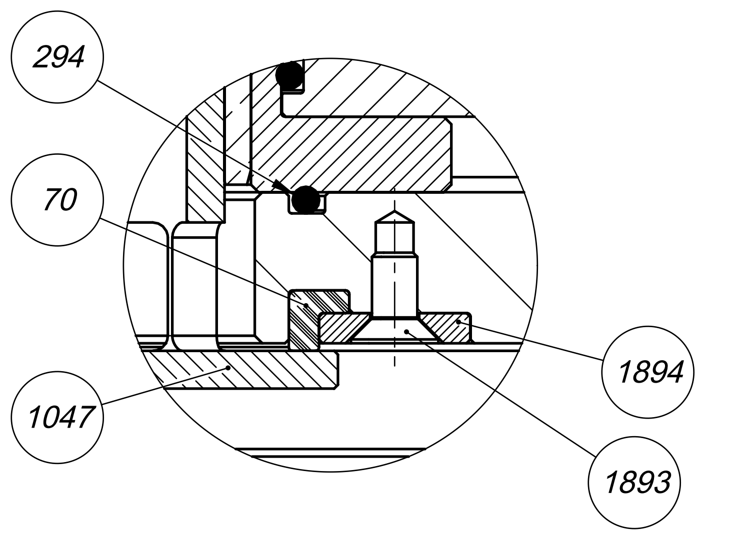
PESO VÁLVULA: 53 kg.



SECCIÓN A-A



SECCIÓN B-B



DETALLE Z

REV	Description	Drawn	Date	Check	Date	Approv.	Date
3	Modificado marcado con 3	A.López	08-01-18		08-01-18		08-01-18
2	Asignar nuevas posiciones y descripciones, añadir mats. y referencias	B. Royo	31/05/16		31/05/16		31/05/16
1	Añadidas piezas marcadas con	A.López	03/03/16		03/03/16		03/03/16

RINGO VALVULAS

Detail
GENERAL ASSEMBLY
& LIST OF MATERIALS

Title:
GLOBO SEGURIDAD
1" 300#

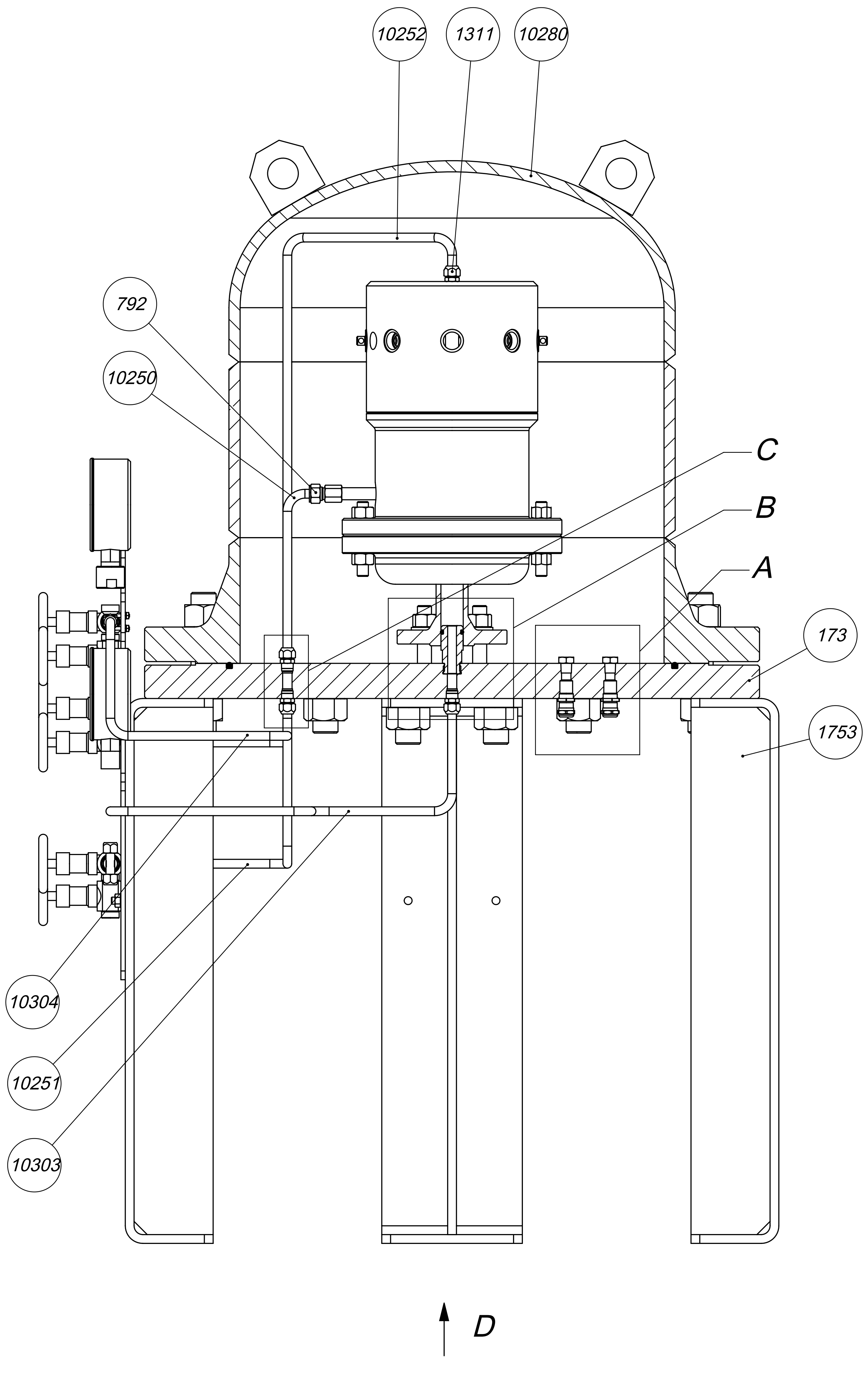
Drawn	A.LOPEZ	Date	18-02-16	Gen Tol	Escale	Size	Drwg No.
Check			18-02-16	Sheet 1 / 1		A2	RV-E1306
Approved			18-02-16				

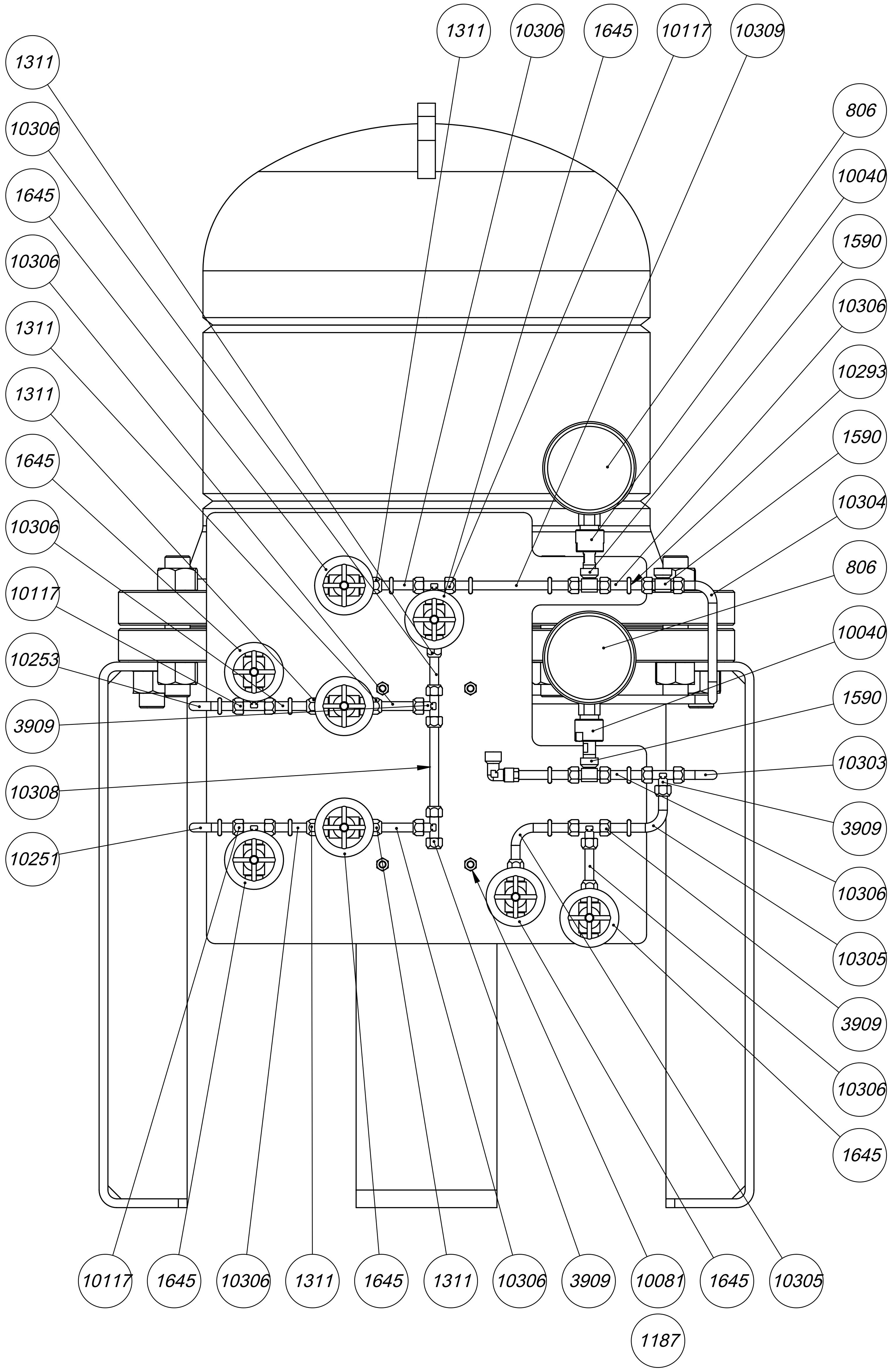
REV 3

ANNEX II

ASVAD VALVE TEST BENCH DIMENSIONAL SCHEMA

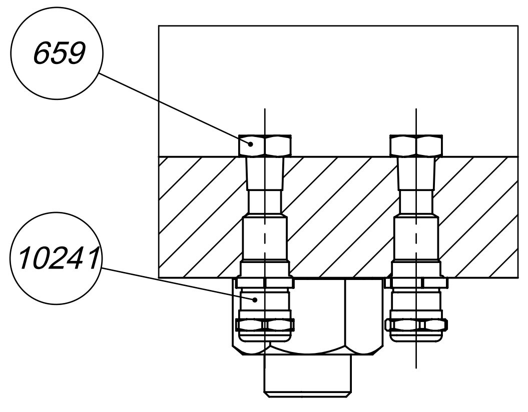
UT-A2-000230-0





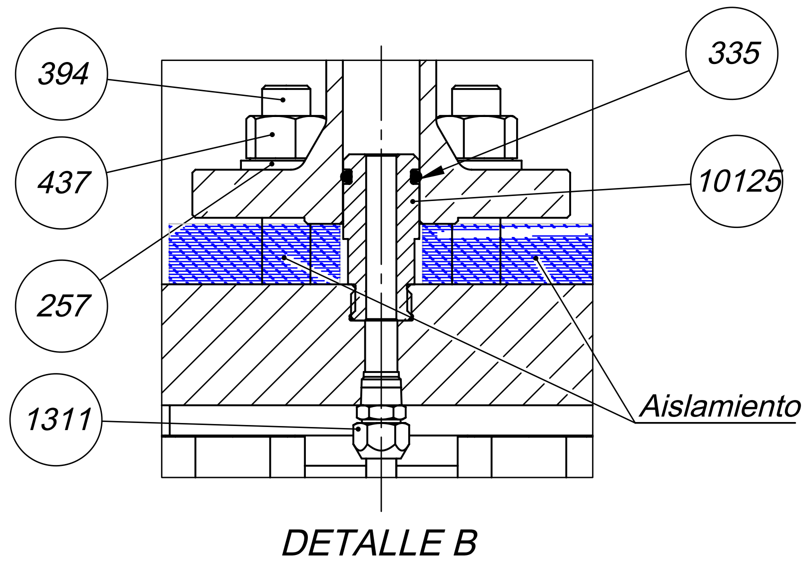
LISTA DE MATERIALES

POS.	CANT.	NOMBRE	DESCRIPCIÓN
173	1	BRIDA ENTRADA	UT-A3-000952-0
257	4	JUNTA BRIDA	UT-A4-001494-0
298	1	JUNTA TORICA CIERRE	CORDÓN TÓRICO Ø7
335	1	JUNTA TORICA EJE	2-210
375	8	ESPARRAGO TAPA INFERIOR	1" 1/8 UN x 160
394	4	TORNILLO SUJECCIÓN	DIN976 M16 x 90
437	4	TUERCA SUJECCIÓN VÁLVULA	DIN934 M16
609	1	PLACA SOPORTE	UT-A3-000953-0
659	2	TAPÓN	1/4" NPT
792	1	RACOR	MECESA 2 KUH 10
806	2	MANOMETRO	MANOMETRO 25BAR
1187	4	ESPÁRRAGO SUJECCIÓN PLACA	DIN976 M8 x 35
1230	8	ESPÁRRAGO SUJECCION PATAS	1" 1/8 UN x 90
1231	24	TUERCA ESPARRAGO SUJECCIÓN PATAS	1" 1/8 UN
1311	15	RACOR RECTO 1/4" NPT A TUBING OD10	MECESA 2 KUM 10
1590	3	RACOR EN "T"	MECESA 2 KCT 10
1645	8	VALVULA SELECTORA	MECESA 062HG2
1753	4	SILLETA	UT-A3-000954-0
1822	1	CODO 90º 1/4"	MECESA 2 KCH 10
3909	4	RACOR "T" UNIÓN	MECESA 10 KTU 10
10040	2	CONJUNTO RACOR BANCO PRUEBAS	UT-A4-000028-0
10081	8	TUERCA SUJECCIÓN PLACA	DIN934 M8
10117	3	TE	MECESA 2 KTC 10
10125	1	ACOPLADOR MACHO	UT-A4-001495-0
10241	4	PASAMUROS	SES A1060.17.105
10250	1	TUBO 1	UT-A4-001484-0
10251	1	TUBO 2	UT-A4-001485-0
10252	1	TUBO 3	UT-A4-001486-0
10253	1	TUBO 4	UT-A4-001487-0
10280	1	ÚTIL PRUEBAS MONTAJE	UT-A3-000951-0
10293	12	ABRAZADERA	MECESA TUBO 1/8"
10303	1	TUBO 5	UT-A4-001488-0
10304	1	TUBO 6	UT-A4-001489-0
10305	2	TUBO 7	UT-A4-001490-0
10306	9	TUBO 8	UT-A4-001491-0
10307	1	TUBO 9	UT-A4-001492-0
10308	1	TUBO 10	UT-A4-001493-0
10309	1	TUBO 11	UT-A4-001497-0



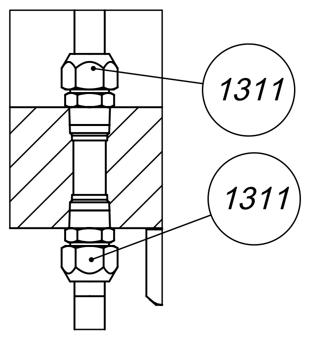
DETALLE A

-Detalle conexión cableado.
Se conectarán 4 pasamuros,y se
taponarán los 2 agujeros restantes.



DETALLE B

-Detalle toma nitrógeno válvula.
Se aislará la conexión entre la brida inferior
y la placa de la cámara de pruebas.



DETALLE C

-Detalle conexión maniobra de la válvula.
En las tomas de armado y desarmado se
colocarán racores arriba y abajo.
En la de presurización de la válvula solo abajo.

Rev.	Cambio	Por	Fecha	Compr.	Fecha	Aprob.	Fecha

Tolerancias no especificadas

desde	hasta	±
0	75	0.3
75	200	0.5
200	500	1
500	Over	1.5

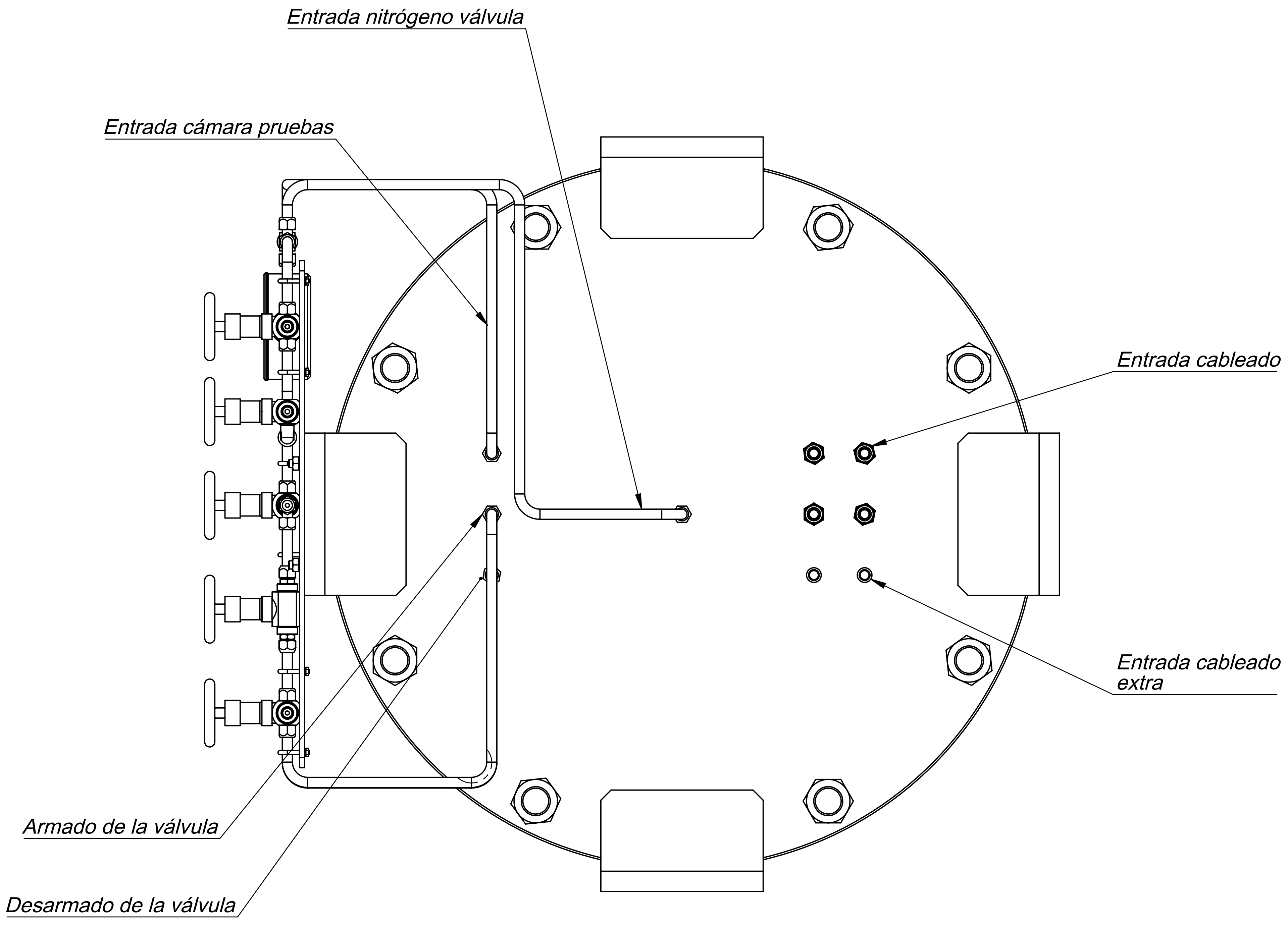
angulos ± 1/2°
acabado superficial 6.3 Ra
matar aristas 0.5 maximo

RINGO VALVULAS

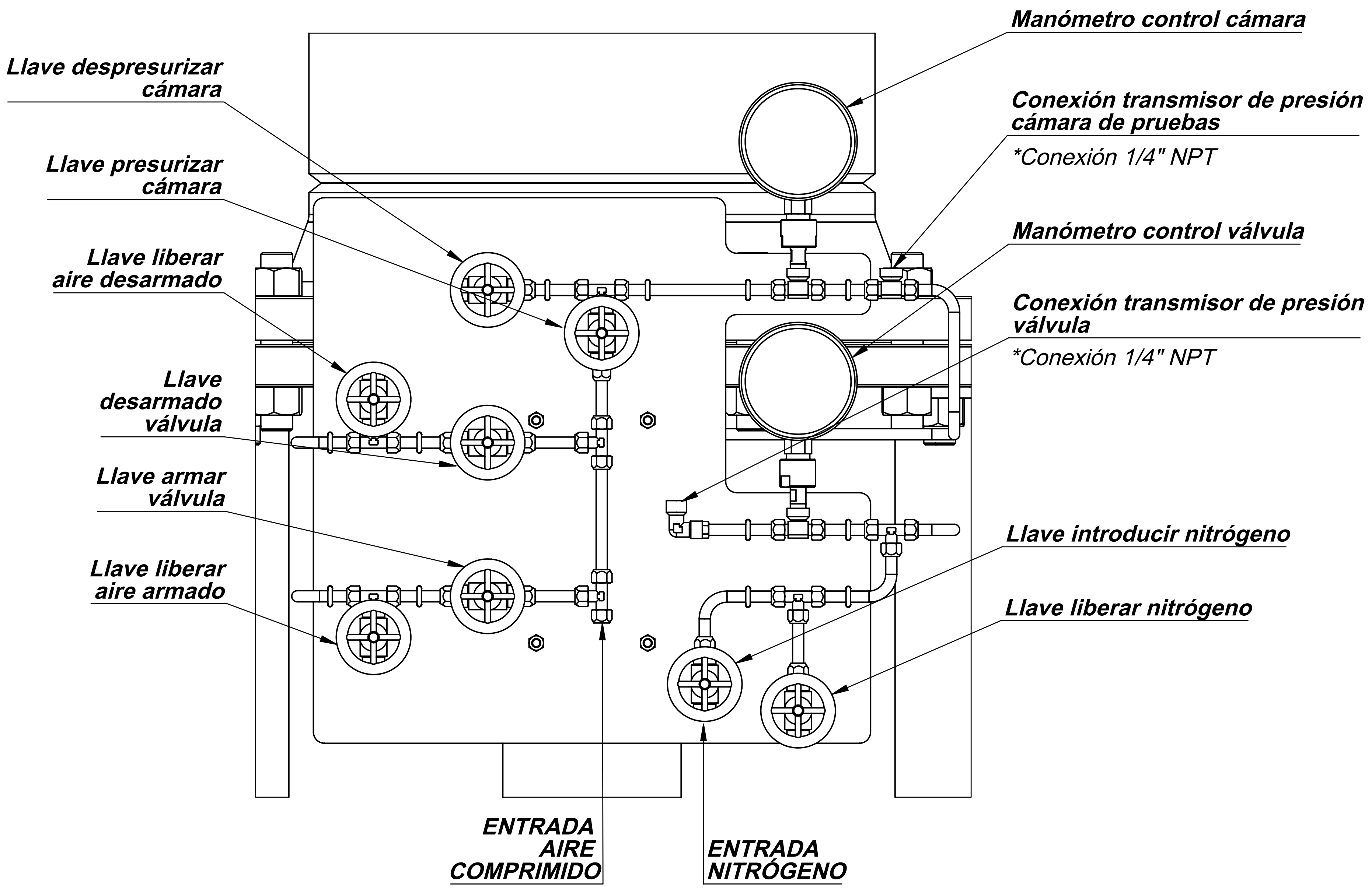
Peso	Escala	Designacion:
409.35 (Kg)	1:5	ÚTIL PRUEBAS 10214

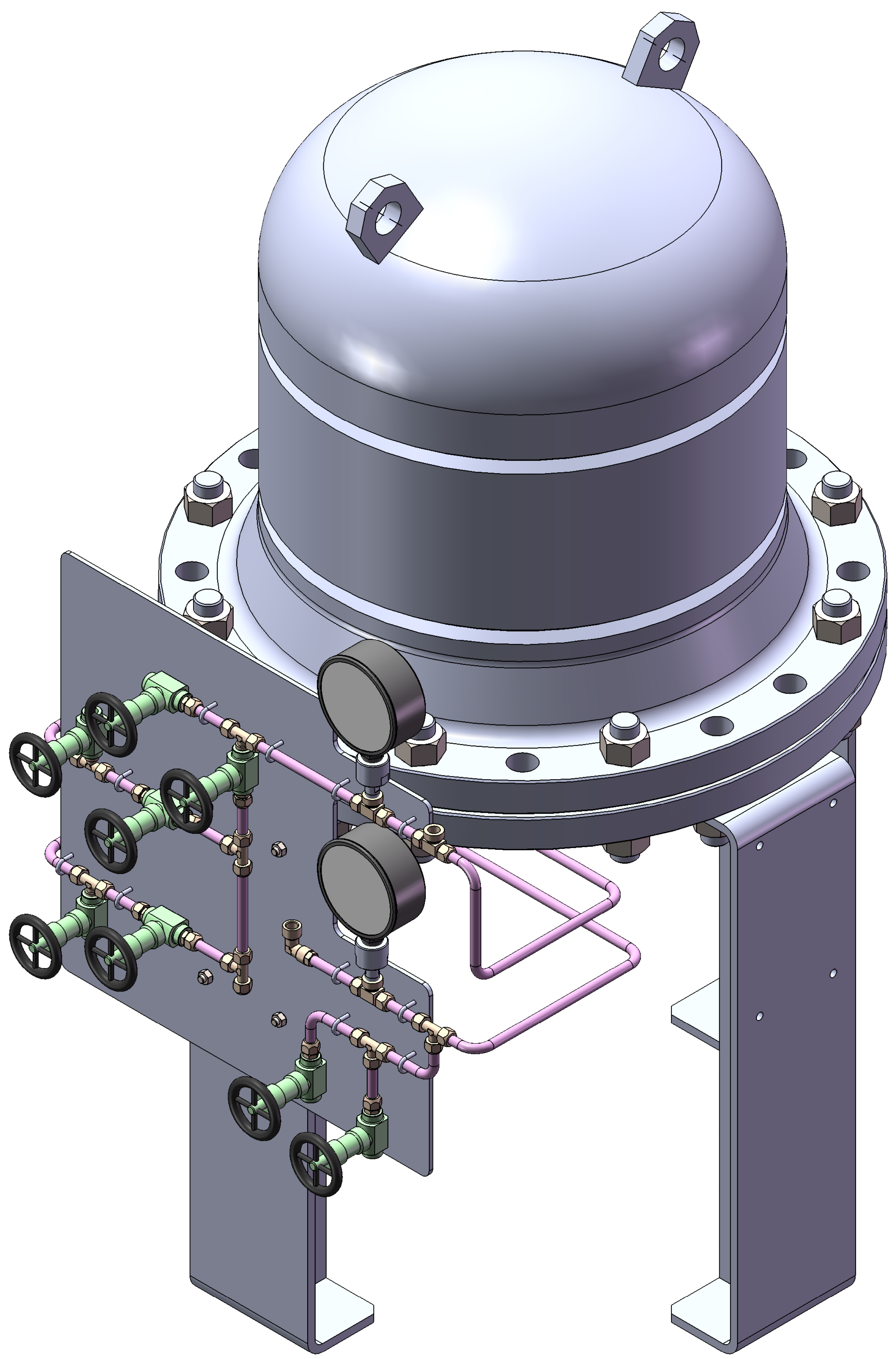
Dibujado	A.LOPEZ	Fecha	14-03-17
Compr.			14-03-17
Aprob.			14-03-17

Tipo Valvula	Paso	Presion	Dibujo No:	Pag.	Rev.
UTILLAJE	-	-	UT-A2-000230	1/2	0



VISTA D





Rev.	Cambio	Por	Fecha	Compr.	Fecha	Aprob.	Fecha

Tolerancias no especificadas

desde	hasta	±
0	75	0.3
75	200	0.5
200	500	1
500	Over	1.5

angulos ± 1/2°
acabado superficial 6.3 Ra
matar aristas 0.5 maximo

RINGO VALVULAS

Peso: 409.35 (Kg)
Escala: 1:5
Designacion: ÚTIL PRUEBAS
10214

Dibujado: A.LOPEZ — Fecha 14-03-17
Compr. — 14-03-17
Aprob. — 14-03-17

Tipo Valvula	Paso	Presion	Dibujo No:	Pag.	Rev.
UTILLAJE	-	-	UT-A2-000230	2/2	0

ANNEX III

ASVAD VALVE VALIDATION TESTING PROCEDURES

(With Results)

- IN8-3-695 r1
- IN8-3-696 r0
- IN8-3-697 r2
- IN8-3-698 r0
- IN8-3-699 r1
- IN8-3-700 r0

RINGO VALVULAS	INSTRUCCION	**Nº:** IN8-3-695 **Revisión:** 1 **Fecha:** 10/06/2018 **Página:** 1 de 12

Título: Plan de Pruebas de Validación de la válvula ASVAD WO-6056

Revisado:	**Aprobado:**
RESPONSABLE CALIDAD	RESPONSABLE OPERACIONES

0. HISTORIAL DE REVISIONES.

Rev.	Fecha/*Date*	Asunto/*Subject*	Aprobado/*Approved*	Revisado/*Revised*
0	04/01/2018	Emisión Inicial	JMGM	MO
1	10/06/2018	*Revisión pruebas*	JMGM	MO

1. OBJETO.

Este documento tiene por objeto definir las pautas necesarias para llevar a cabo la secuencia de pruebas para la validación de la válvula ASVAD (WO-6056) para su uso en Centrales Nucleares.

2. CAMPO DE APLICACIÓN.

Esta instrucción aplica a las válvulas fabricadas por Ringo Válvulas S.L. en la obra WO-6056.

3. REFERENCIAS .

ANSI / ASME QME -1- 2012
Código ASME Sección III, Subsección NB Edición 2015
ISO-5208
ANSI / ASME B16.34 Ed. 2013

4. FORMATOS A SER USADOS.

El formato del Anexo I (F8-3-695-1) se usará como registro de la realización de las pruebas. Durante toda la secuencia de pruebas, se anotará en el mismo las fechas / horas de realización de cada prueba y los datos principales de las mismas.

También se anotaran en este registro cualquier otra circunstancia, cambio o evento que pueda ser considerado relevante. Este registro constituirá un documento incluido en el dossier final de validación. Este registro incluirá las firmas del personal de Ringo Válvulas S.L., y las del inspector autorizado y/o del Inspector del cliente.

Podrán utilizarse tantas hojas como sean necesarias, numerándolas sucesivamente a medida que vayan utilizándose. Una vez finalizado el proceso de validación, se indicara en cada hoja el número total de formatos usados.

El formato del Anexo II (F8-3-695-2), constituye un resumen del cumplimiento de los procedimientos realizados. En él se consignará si se cumplen los criterios de aceptación, y si hay alguna desviación sobre los mismos y las observaciones que los inspectores crean convenientes. Incluirá las mismas firmas que el anterior.

5. PERSONAL.

El personal responsable de la realización de la presente instrucción deberá estar cualificado según IN6-1-4: “Instrucción para la cualificación del personal de inspección, exámenes y pruebas”.

El personal responsable de la realización de la presente instrucción deberá cumplir con las normas de seguridad INMASS-1-7: “Normas de seguridad para prueba de válvulas”.

Precaución: Poner atención en el uso de EPI’s adecuados durante las pruebas.

Las pruebas serán presenciadas y validadas por una persona del Departamento de Garantía de la Calidad de Ringo Válvulas. Así mismo las pruebas pueden ser presenciadas y validadas por un inspector del cliente y/o por un inspector de una agencia autorizada por el cliente.

6. MATERIALES Y EQUIPOS.

Serán definidos en cada procedimiento utilizado.

7. PLAN DE PRUEBAS DE VALIDACION.

Se ha diseñado un plan de pruebas que verifica el cumplimiento con las especificaciones de diseño de la Válvula, y su capacidad de soportar las condiciones de funcionamiento postuladas durante un accidente DBA.

Dicho conjunto de pruebas demuestran la idoneidad del diseño y ejecución de la válvula ASVAD para su uso en la función de evitar la inyección del nitrógeno de los tanques acumuladores al RCS y en concreto para su apertura rápida cuando la presión en su cámara disminuya por debajo de un valor concreto preajustado mediante la tensión mecánica en su muelle.

El plan de ejecución de las pruebas va a ser el siguiente:

7.1. Inspección Inicial.
Se realizara una inspección inicial del estado del prototipo a probar según IN8-3-700.

7.2. Se realizará la secuencia de pruebas iniciales a temperatura ambiente:

7.2.1. Prueba de sobrepresión y fugas según IN8-3-696.
7.2.2. Prueba de pilotaje según IN8-3-698.
7.2.3. Pruebas de disparo (5 series) según IN8-3-697.

7.3. Se realizará la secuencia de pruebas siguiente a temperatura DBA:

7.3.1. Prueba de disparo a 100ºC (5 series) atmosférico IN8-3-697.
7.3.2. Prueba de disparo a 140ºC (5 series) atmosférico IN8-3-697.
7.3.3. Pruebas de disparo a distintas temperaturas y presiones IN8-3-697.

7.4. Se realizará Proceso de envejecimiento acelerado (>15h @ 120ºC).
Básicamente se mantendrá el prototipo calificado a 120 ºC durante un periodo superior a 15 h. Adjuntar registro de la temperatura.

7.5. Se realizará la secuencia de pruebas funcionales en condiciones de accidente DBA:

7.5.1. Prueba de disparo Pre-DBA a 120º @ 2 bar (abs). Según procedimiento IN8-3-699 (hasta apdo. 7.2).

7.5.2. Tiempo de calificación ambiental (4 días). Según procedimiento IN8-3-699 (apdo. 7.3 y 7.4).

7.5.3. Prueba de disparo a 120º @ 2 bar (abs). Según procedimiento IN8-3-699 (apdo. 7.5 hasta final).

7.5.4. Se realizará prueba funcional post DBA a temperatura/presión ambiental. según IN8-3-699 (apdo. 7.6).

7.6. Inspección Final.
Se realizara una inspección final del estado del prototipo según IN8-3-700.

7.7. Se realizarán los Cálculos de comportamiento sísmico y se adjuntaran al dossier final.

8. CRITERIOS DE ACEPTACION.

Esta instrucción no tiene criterios de aceptación. Los Criterios de aceptación para cada una de las pruebas referenciadas serán los incluidos en las mismas.

9. ANEXO I

VER FORMATO F8-3-695-1

10. ANEXO II

VER FORMATO F8-3-695-2

RINGO VALVULAS	**LOG REPORT** **ASVAD VALVE** (WO-6056) **VALIDATION TESTS**

RINGO VÁLVULAS, S.L. **Polígono Empresarium** **Calle Romero nº 6** **50720 Zaragoza (España)**	PROCEDURE IN8-3-695 Rev. 1	Sheet 1 from 7

DATA 21/2/18 TIME 10:00 ACTIVITY: INITIAL INSPECTION AND PREPARATION

NOTES:

- THE TEST BENCH IS INSTALLED
- INITIAL INSPECTION W PROCEDURE IN8-3-700
  - FIRST ONLY BY THE EXTERIOR. → OK
  - THE MIDDLE BODY WERE DISMOUNTED → INSPECTION OK
    SOME GASKETS ARE REPLACED.
- IN THE BENCH, THE CABLE GLANDS ARE CHANGED.
- INSTALLED A FLEXIBLE TUBE TO OPEND THE VALVE.

13:00

- INSTALLED A MOTION SENSOR IN THE OBTURATOR.
- DURING THE ASSEMBLY, THE BODY GASKET IS DAMAGED, THEN IS REPLACED BY A NEW ONE.
- THE VALVE REMAINS DISPONIBLE TO TEST.

RINGO Executed	RINGO Quality Insp.	ASVAD INTL SL Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com Client Inspector.	TÜV SÜD Iberia, S.A.U. Authorized Inspector.

RINGO VALVULAS	**LOG REPORT** **ASVAD VALVE** (WO-6056) **VALIDATION TESTS**

RINGO VÁLVULAS, S.L. **Polígono Empresarium** **Calle Romero nº 6** **50720 Zaragoza (España)**	PROCEDURE IN8-3-695 Rev. 1	Sheet 2 from 7

DATA 22/ 2/ 18 TIME 8:00 ACTIVITY: OPENING/ CLOSING TEST. OVERPRESURE TEST

NOTES:

- 10 SHOOTS (OPENINGS) ARE DONE. PRESSURE (MEAN) = 12,81 Bar
- THE IN8-3-698 PROCEDURE STARTED. → OK.

10:00 - CLOSING PRESSURE 2,9 BAR. MAX PRESURE TESTED 15 bar
- OPENING " 3,5 bar. " " " 15 bar

DURING THE TEST, THE UPPER GASKET IS DAMAGED & CHANGED

12:00 THE IN-8-3-696 PROCEDURE STARTED

- PRESSURE = 110% PD = 14,1 bar → 5' NO LEAKS OBSERVED
- " = 100% PN = 50 bar → 10' " " "
- " = 150% PN = 75 bar → 10' " " "
- " = 110% PD = 14,1 bar 5' " " "

THE LEAK STARTS AT 13,3 bar (1 bar BEFORE THE OPENING)

23/12/18 8:00

- 10 INITIAL SHOOTS ARE DONE → MEAN PRESSURE = 12,38 bar
- PROCEDURE IN8-3-692 STARTED (
  - LOWER RANGE – 12,38 bar
  - UPPER RANGE – 20,62 bar
  - MEAN RANGE – 16.20 bar @ 16.5°C
- ASSEMBLED THE HEATING CABLES
- " THE ISOLATING COAT.
- READY TO CONTINUE TESTING THE NEX DAY.

	RINGO	**ASVAD INTL SL** Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com	TÜV SÜD Iberia, S.A.U. A-81670614
RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.

RINGO VALVULAS	**LOG REPORT** **ASVAD VALVE** (WO-6056) **VALIDATION TESTS**

RINGO VÁLVULAS, S.L. **Polígono Empresarium** **Calle Romero nº 6** **50720 Zaragoza (España)**	PROCEDURE IN8-3-695 Rev. 1	Sheet 3 from 7

DATA 26/2/18 TIME 8 00 ACTIVITY: SHOOTING TEST AT TEMPERATURE

NOTES:

- A SMALL LEAK DETECTED IN THE CHECK VALVE ⇒ PLUG.
- CHANGED THE CABLE BETWEEN TAPS BY A FLEXIBLE ONE

10:30 . HEATING TO 120°C STARTED . PROCEDURE IN83-697.

12:16 - 120°C REACHED

- 6 SHOOTS DONE @ 120°C → 16,66 bar @ 122,9 °C.

13:00 - HEATING TO 150° STARTED

13:50 - 150°C REACHED

- 8 SHOOTS DONE @ 150°C → 15,35 bar @ 148,3°C.

16:26 - COOLING TO 120°C.

- THE HEATER IS PLACED IN OFF

• 4h 10' ABOVE 120°C

• 1 h 36' AT 120°C

• 30' AT 150 °C

12/6/18 8:00

- ALL THE GASKETS IN THE VALVE ARE REPLACED.
- THE VALVE IS LEFT IN THE BENCH READY TO BE TESTED.

RINGO Executed	RINGO Quality Insp.	ASVAD INTL SL Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com Client Inspector.	TÜV SÜD TÜV SÜD Iberia S.A.U. A-81670414 Authorized Inspector.

RINGO VALVULAS

LOG REPORT
ASVAD VALVE (WO-6056)
VALIDATION TESTS

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

PROCEDURE
IN8-3-695 Rev. 1

Sheet 4 from 7

DATA 13/6/18 TIME 8:30 ACTIVITY: SHOOTING TEST IN8-3-697 R0

NOTES:

8:30 - INSTRUMENTATION INSTALLATION
10:30 - HEATING CABLES INSTALLED W TERMIC INSULATION.
11:00 - SHOOTING TEST AT 20°C.
13:00 - " " @ 80°C
15:05 - " " @ 120°C atm.
15:15 - " " @ 120°C @ 3,06 bar (abs)
- AGEING PROCESS INITIATED.
16:00 - SHOOTING TEST @ 140°C
17:00 - EXPULSION TAPS TEST. @ 120°C.

14/6/18 9:00
9:00 - SHOOTING TEST @ 120°C.
10:00 - THERE IS PROBLEMS (LEAKS) WITH THE TAPS.
STARTED IN8-3-699 PROCEDURE. NO PERFECT ISOLATION GRANTED.
12:30 PROCEDURE ABORTED BY THE LEAKS
15:06 HEATING @ 120°C STOPPED
AGEING ENDED

RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.
		ASVAD INTL SL Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com	TÜV SÜD Iberia, S.A.U.

RINGO VALVULAS

LOG REPORT

ASVAD VALVE (WO-6056)

VALIDATION TESTS

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

PROCEDURE

IN8-3-695 Rev. 1

Sheet 5 from 7

DATA 25/7/18 TIME 8 00 ACTIVITY: SHOOTING TEST IN8-3-692 R1

NOTES:

8:30 - INSTRUMENTATION INSTALLATION.
10:52 - SHOOTING TEST @ P. AMB / T. AMB
11:18 - " " @ 1 BAR(R) / "
11:30 - " " @ 2 BAR (R) "
11:37 - " " @ 3 BAR (R) "
11:45 - " " @ 4 bar (R) "
11:55 - " " @ 5 bar (R) "
12:51 - " " @ 1,12 bar (A) @ 40°C
13:03 - " " @ 3 bar (a) @ 40°C
13:10 - " " @ 0,98 bar (a) @ 40°C
15:35 - " " @ 0,984 bar (a) @ 100°C
15:43 - " " @ 1,99 bar (a) @ 100°C
17:01 - " " @ 3 bar (a) @ 140°C
17:07 - " " @ 3,76 bar (a) @ 140°C
17:14 - " " @ 0,984 bar (a) @ 140°C
18:00 - THE VALUE ARE ARMED WITH 50 bar (110% PN) IN THE PRESSURE CHAMBER. 5,5 bar(R) ARE APLIED TO THE BENCH.
PROCEDURE IN8-3-699 (R1) STARTED. THE VALVE IS LEFT AT 75 °C.

		ASVAD INTL SL Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com	TÜV SÜD Iberia, S.A.U. A-61670614
RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.

RINGO VALVULAS

LOG REPORT

ASVAD VALVE (WO-6056)

VALIDATION TESTS

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

PROCEDURE

IN8-3-695 Rev. 1

Sheet 6 from 7

DATA 26/7/18 TIME 7:00 ACTIVITY: IN8-3-699

NOTES:
7:00 HEATING STARTED TO 160°C.
15:00 157°C REACHED
18:30 SETPOINT CHANGED TO 120°C. → (3,5h @ 160°C)
THE VALVE REMAINS DURING 4 DAYS (50bar / 5,5bar / 120°C)

30/7/18 AFTER SEEING THE GRAPH, WE OBSERVED THAT THERE IS NO ENOUGH TIME @ 160°C. DECIDED TO MAKE AN EXTRA HEATING TIME.
10:30 - SHOOTING TEST ARE DONE @ 120°C / 50bar | 2bar(a)
RESULT → 12,584 Bar @ 127,8°C
13:00 HEATING TO 160° STARTED AGAIN.
18:00 157°C REACHED

31/7/18 TEMPERATURE SETPOINT CHANGED TO 120°C.
8:00 -
10:39 - POST-DBA SHOOT DONE → 17,39 bar(R) → OK
11:00 COOLING INITIATED. THE ISOLATION AND HEATING CABLES ARE DISASSEMBLED.
12:30 POST-DBA SHOOT DONE → 16,90 bar R @ 56°C OK

ASVAD INTL SL
Arnaldo Laborda Rami
Gerente / CEO
alaborda@asvad-nuclear.com

TÜV SÜD Iberia, S.A.U.
A-81670614

RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.

RINGO VALVULAS

LOG REPORT

ASVAD VALVE (WO-6056)

VALIDATION TESTS

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

PROCEDURE

IN8-3-695 Rev. 0

Sheet 2 from 7

DATA 20/8/18 TIME 12:00 ACTIVITY: FINAL INSPECTION IN8-3-700

NOTES:

- THE VALVE IS DIS ASSEMBLED AND INSPECTED
- ALL THE GASKETS ARE CHANGED

ASVAD INTL SL
Arnaldo Laborda Rami
Gerente / CEO
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TÜV SÜD Iberia, S.A.U.

RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.

RINGO VALVULAS

ASVAD VALVE (WO-6056)
VALIDATION REPORT

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

PROCEDURE
IN8-3-695 Rev. 1

Sheet 1 from 3

DATE 21/2/18 HOUR 13:20

ACTIVITY: Initial Inspection.

PROCEDURE: **IN8-3-700**

The acceptance criteria are met? [✓ YES ∧] NO ∇

There is any deviation from procedure? YES ∧ [✓ NO ∇]

NOTES:
- FIRST INSPECTION EXTERNAL → OK
- MIDDLE BODY DISMOUNTED AND INSPECTED → OK

DATE 22/2/18 HOUR 18:00

ACTIVITY: Overpressure & leaks Test.

PROCEDURE: **IN8-3-696**

The acceptance criteria are met? [✓ YES ∧] NO ∇

There is any deviation from procedure? YES ∧ [✓ NO ∇]

NOTES:
SOME ISSUES WITH CLOSING PISTON.
DISMOUNTED / LUBRICATED . TEST OK.

DATE 22/2/18 HOUR 18:00

ACTIVITY: Opening/closing Test.

PROCEDURE: **IN8-3-698**

The acceptance criteria are met? [✓ YES ∧] NO ∇

There is any deviation from procedure? YES ∧ [✓ NO ∇]

NOTES:
ALL TEST OK.

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RINGO VALVULAS

CERTIFICADO RESUMEN DE LAS PRUEBAS DE VALIDACION DE LA VALVULA ASVAD (WO-6056)

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

PROCEDURE
IN8-3-695 Rev. 1

Sheet 2 from 3

DATE 25/7/18 HOUR 18:00

The acceptance criteria are met? [✓ YES ∧] NO ∇

ACTIVITY: Trip Test (Initial).

There is any deviation from procedure? REVISED TO REV 1 [✓ YES ∧] NO ∇

PROCEDURE: **IN8-3-697**

NOTES:
- RANGE TEST DONE 23/2/18 – OK.
- SHOOTING TEST DONE 25/7/18 (REV 1 → OK.
- AGING PROCESS DONE 13/6/18

DATE 14/6/18 HOUR 18:00

The acceptance criteria are met? [✓ YES ∧] NO ∇

ACTIVITY: Accelerated ageing.

There is any deviation from procedure? YES ∧ [✓ NO ∇]

PROCEDURE: **IN8-3-699**

NOTES:
AGEING PROCESS DONE @ 150°C.
DURING 21,4 h WITH PROCEDURE
IN8-3-697.

DATE 31/7/18 HOUR 18:00

The acceptance criteria are met? [✓ YES ∧] NO ∇

ACTIVITY: Ambiental test.

There is any deviation from procedure? [✓ YES ∧] NO ∇

PROCEDURE: **IN8-3-699**

NOTES:
AFTER 4 DAYS, IS DETECTED THAT THERE IS NOT ENOUGH TIME AT 150°C. A NEW HEATING PERIOD OF 19 H ARE INCLUDED AT THE END @ 160°C.

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RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.
			TÜV SÜD Iberia S.A.U.

RINGO VALVULAS

CERTIFICADO RESUMEN DE LAS PRUEBAS DE VALIDACION DE LA VALVULA ASVAD (WO-6056)

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

PROCEDURE
IN8-3-695 Rev. 1

Sheet 3 from 3

DATE 31/7/18 HOUR 18:00

ACTIVITY: Trip test (post DBA).

PROCEDURE:

IN8-3-697

The acceptance criteria are met? [✓ YES ∧] NO ∇

There is any deviation from procedure? [✓ YES ∧] NO ∇

NOTES:
AFTER THE SECOND HEATING PERIOD (19h) THE SHOOTING TEST IS DONE AFTER MORE THAN 10h @ 160°C THE FIRST SHOOT IS OK. THEN, 4 MORE SHOOTS ARE DONE WITH THE SAME RESULT.

DATE 20/8/18 HOUR 12:00

ACTIVITY: Final Inspection.

PROCEDURE:

IN8-3-700

The acceptance criteria are met? [✓ YES ∧] NO ∇

There is any deviation from procedure? YES ∧ [✓ NO ∇]

NOTES:
ALL OK.

DATE ___/___/___ HOUR ___:___

ACTIVITY:

PROCEDURE:

The acceptance criteria are met? YES ∧ NO ∇

There is any deviation from procedure? YES ∧ NO ∇

NOTES:

RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.
		ASVAD INTL SL Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com	TÜV SÜD TÜV SÜD Iberia, S.A.U

RINGO VALVULAS	INSTRUCCION	**Nº:** IN8-3-696 **Revisión:** 0 **Fecha:** 04/01/18 **Página:** 1 de 8
Título: Prueba de sobrepresión y de fugas de la válvula ASVAD WO-6056		

Revisado:	**Aprobado:**
RESPONSABLE CALIDAD	RESPONSABLE OPERACIONES

0. HISTORIAL DE REVISIONES.

Rev.	**Fecha/*Date***	**Asunto/*Subject***	**Aprobado/*Approved***	**Revisado/*Revised***
0	04/01/2018	Emisión Inicial	JMGM	MO

1. OBJETO.

Este documento tiene por objeto definir las pautas necesarias para llevar a cabo la prueba estructural de sobrepresión y la prueba de fugas para la válvula ASVAD correspondiente a la WO-6056.

2. CAMPO DE APLICACIÓN.

Esta instrucción aplica a las válvulas fabricadas por Ringo Válvulas S.L. en la obra WO-6056.

3. REFERENCIAS .

Código ASME Sección III, Subsección NB-6000 Edición 2015
ISO-5208:2008 (E)
ANSI / ASME QME -1- 2012

4. FORMATOS A USAR.

Los formatos del Anexo I se usarán como registro de los resultados de las pruebas y la aceptación de Ringo Válvulas S.L., del inspector autorizado o tercera parte y del Inspector del cliente. Se rellenaran y firmarán ambos formatos, en español e inglés.

Los datos de prueba requeridos tales como presión, pérdidas, duración de la prueba, etc, serán indicados en la hoja de pruebas antes de realizarse las pruebas. Los resultados reales serán registrados durante la realización de la prueba.

5. PERSONAL.

El personal responsable de la realización de la presente instrucción deberá estar cualificado según IN6-1-4: “Instrucción para la cualificación del personal de inspección, exámenes y pruebas”.

El personal responsable de la realización de la presente instrucción deberá cumplir con las normas de seguridad INMASS-1-7: “Normas de seguridad para prueba de válvulas”.

Precaución: Poner atención en el uso de EPI’s adecuados durante las pruebas.

Las pruebas serán presenciadas y validadas por una persona del Departamento de Garantía de la Calidad de Ringo Válvulas. Así mismo las pruebas pueden ser presenciadas y validadas por un inspector del cliente y/o por un inspector de una agencia autorizada por el cliente. Firmaran las hojas del anexo I.

6. MATERIALES Y EQUIPOS.

6.1. Fluido.

El fluido de pruebas para esta prueba será nitrógeno industrial a temperatura ambiente. También es aceptable su realización con aire comprimido seco o sintético.

Se utilizará líquido buscafugas para la detección de las posibles fugas que pudieran darse.

6.2. Banco de pruebas.

Las pruebas se realizaran con la válvula ASVAD montada en posición vertical en la toma correspondiente del banco de pruebas diseñado especialmente para este fin.

Precaución: la válvula se instalará de forma que en ningún caso la descarga de la misma pueda causar daños tanto a personas como a la instalación.

6.3. Manómetros.

Los manómetros de prueba estarán calibrados de acuerdo con ASME III, cláusula NB-6400.
Se seleccionarán de tal modo que la presión de prueba estará entre el 10% y el 90% del fondo de escala. La incertidumbre de los manómetros será menor de un 5% del rango. Se requiere un manómetro capaz de medir 80 Kg/cm2.

6.4. **Termómetro.**

Se utilizará un termómetro calibrado con una incertidumbre menor de ± 2ºC. La temperatura durante la prueba estará entre 5º C y 40ºC.

Prerrequisito: Antes de iniciar las pruebas comprobar que los equipos a utilizar se encuentran en su periodo de validez de calibración. Anotar su identificación en la hoja de registro.

7. PRUEBAS DE SOBREPRESION Y DE FUGAS.

Prerrequisito: Antes de iniciar las pruebas comprobar la integridad de la válvula, la ausencia de marcas o golpes, así como de cualquier otro daño que pueda afectar al funcionamiento de la misma.

Precaución: No manipular los elementos de la válvula o del sistema de prueba bajo presión. Si es necesario realizar algún reapriete, o reajuste de conexiones despresurizar completamente el sistema antes de proceder a ello.

Precaución: Una vez armada, la despresurización de la válvula por debajo de su punto de disparo, provoca el disparo de la válvula. Riesgo de proyecciones.

Precaución: Dado que la prueba se realiza con gas, proteger el entorno de la válvula mediante barreras físicas que eviten los riesgos de proyección de misiles que puedan derivarse de un fallo estructural en la misma o en el sistema de prueba. Minimizar la parte de la instalación sometida a presión.

La presión de prueba para todas las válvulas sujetas a esta instrucción es del 150% de su Presión Nominal (PN). La presión de prueba para detectar fugas es del 110% de su Presión de Disparo (PD). Anotar ambas en el formato de prueba. Ir anotando los sucesivos valores obtenidos durante la ejecución de las pruebas.

7.1. Montar el sistema de pruebas según se indica en la figura 1 del anexo II. Desmontar la tapa superior para poder tener acceso visual a la salida superior del obturador. Ajustar la presión de disparo alrededor del 50% de su rango.

7.2. Realizar una inspección visual previa del conjunto, comprobando que la instalación coincide con lo deseado y la válvula no presenta deterioros.

7.3. Cerrar el obturador de la válvula aplicando aire comprimido en la entrada de armado. Mantener dicha presión mientras la presión en la cámara inferior de la válvula sea inferior al 110% de la presión de disparo.

7.4. Presurizar la cámara inferior de la válvula con una presión inicial de al menos el 110% de su PD. Una vez a esta presión, despresurizar completamente la entrada de aire comprimido de armado.

7.5. Rociar las juntas susceptibles de fugas con el líquido busca fugas. Comprobar que no existen fugas apreciables, y solucionarlas si las hubiera.

7.6. Una vez se ha constatado la ausencia de fugas en las juntas, rociar con liquido buscafugas la salida del obturador principal. Puede usarse un globo estanco para la comprobación de fugas.

7.7. Con la presión mantenida al 110% de la PD, comprobar durante al menos 5 minutos que no se observan burbujas o fugas en la salida del obturador principal.

7.8. Subir progresivamente la presión en la válvula hasta el 100% de su PN comprobando que sigue sin manifestarse ningún tipo de fuga.
Si se detectara alguna fuga, despresurizar completamente el sistema y solucionarla antes de proseguir con la prueba. **Atención: La válvula disparará al despresurizar por debajo del PD.**

7.9. Mantener la presión del 100% de su PN durante al menos 10 minutos. Comprobar durante que no se observan burbujas o fugas en la salida del obturador principal. Comprobar la ausencia de fugas en la zona de la brida.

7.10. Incrementar la presión hasta conseguir la presión de prueba del 150% de PN. Mantener la presión durante al menos 10 minutos. Comprobar que no se observan fugas ni deformaciones en la válvula.

7.11. Disminuir nuevamente la presión hasta el 110% de la PD. Mantener la presión durante al menos 5 minutos. Comprobar que no se observan fugas en la válvula.

7.12. **Precaución: Riesgo de proyecciones al disparar la válvula**.
Disminuir lentamente la presión de la válvula hasta que esta comience a fugar. Anotar esta presión en el anexo.

Seguir disminuyendo lentamente la presión hasta que la válvula dispare. Anotar esta presión en el anexo.

7.13. Una vez terminada la prueba, montar la tapa superior, quedando la válvula lista para realizar otras pruebas.

8. NORMALIZACION.

Si no se van a realizar más pruebas, retirar las conexiones de presión y desmontar la válvula del banco.

9. CRITERIOS DE ACEPTACION.

Los Criterios de aceptación para esta prueba son los siguientes:

Para la prueba de sobrepresión:

- Con la cámara inferior de la válvula presurizada al 150% PN, no se observan fugas de presión en la válvula durante 10 minutos.

Para la prueba de fugas:

- Con la cámara inferior de la válvula presurizada al 110% PD (presión de disparo) no se observan fugas de presión por el obturador de la válvula durante 5 minutos.
- Con la cámara inferior de la válvula presurizada al 100% PN (presión nominal) no se observan fugas de presión por el obturador de la válvula durante 10 minutos.

10. ANEXOS

I. Hoja de datos FORMATO F8-3-696.
II. Configuración de la prueba.

RINGO VALVULAS

TEST CERTIFICATE
OVERPRESSURE AND LEAKS
ASVAD VALVE (WO-6056)

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

TEST PROCEDURE
IN8-3-696 Rev. 0

Sheet 1 of 1

CLIENT ASVAD INTL SL
Ref. CLIENT
SITE WO-6056
ITEM ASVAD-1
DATA 22/2/18

VALVE IDENTIFICATION	SERIAL		NOMINAL PRESSURE PN	50 bar X 1,50 = 75 bar
	MODEL		TRIP PRESSURE PD	12,8 bar X 1,10 = 14,1 bar

VISUAL INSPECTION — VALVE INTEGRITY OK? YES Λ [✓ NO V] — OBSERVED DAMAGES? YES Λ [✓ NO V]

OVERPRESSURE & LEAK TEST

TEST PRESSURE		DESIRED VALUE	OBTAINED VALUE	CORRECT? YES/NO	TEST TIME
110 % PD (UP) =	14.13 bar	No leaks detected	NO LEAK	Y	11'
100 % PN (UP) =	50 bar	No leaks detected	NO LEAK	Y	12'
150 % PN (DOWN) =	75 bar	No leaks detected	NO LEAK	Y	10'
110 % PD (DOWN) =	14,1 bar	No leaks detected	NO LEAK	Y	5'
Leakage start pressure *	12,38 bar	≈ 2 bar before trip	13,3 bar	Y (<1 bar)	n/a
Test Temperature		Between 5 y 40 ºC	17,7 ºC	Y	n/a
Trip Pressure PD		PD = 12,38 bar	12,38 bar	Y	n/a

MEASUREMENT AND TEST EQUIPMENT

DESCRIPTION	IDENTIFICATION NUMBER	CALIBRATION DUE DATE
MANOMETER 0-60 bar / MANOMETER 0-160 bar	RV-434 / RV-195	SEPT-18 / MAR-18
REGISTRER / PRESS. TRANS. 25 bar	2106310 / 2188012	10/5/18 / 1/02/19
TERMOMETER / TEMP. TRANS. 0-200 ºC	2186010 / 2188013	3/5/18 / 2/2/19

Comments: CRONOMETER. 412097 / 27/9/19

* THE CLOSING PISTON WERE LOCKED. IT WAS DISMOUNTED AND LUBRICATED, THE NEW OPENING PRESSURE IS 12,38 BAR. THE LEAK TEST IS REPEATED GIVING 13.3 BAR.

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ANEXO II **CONFIGURACION DE LA PRUEBA**

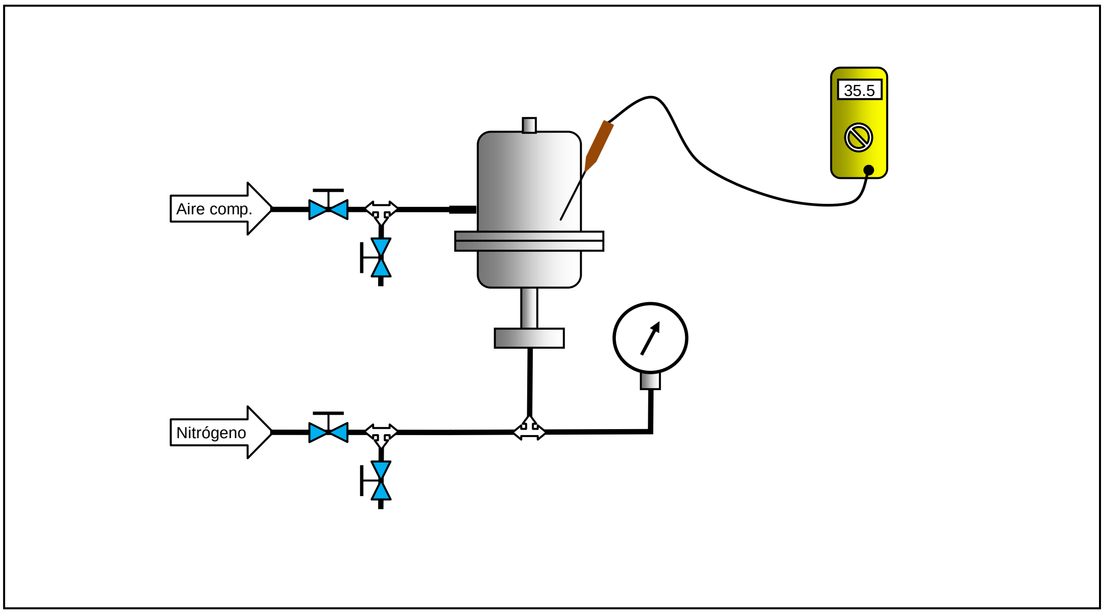


Figura 1. Prueba de Sobrepresión y de fugas.

RINGO VALVULAS	**INSTRUCCION**	**Nº:** IN8-3-697 **Revisión:** 1 **Fecha:** 04/01/18 **Página:** 1 de 18
Título: Pruebas de disparo y Rango de Ajuste de la válvula ASVAD WO-6056		

Revisado: RESPONSABLE CALIDAD	**Aprobado:** RESPONSABLE OPERACIONES

0. HISTORIAL DE REVISIONES.

Rev.	**Fecha/*Date***	**Asunto/*Subject***	**Aprobado/*Approved***	**Revisado/*Revised***
0	04/01/2018	Emisión Inicial	JMGM	MO
1	10/06/2018	*Revisión pruebas*	JMGM	MO

1. OBJETO.

Este documento tiene por objeto definir las pautas necesarias para llevar a cabo la prueba funcional de disparo y la prueba del rango de ajuste del mismo para la válvula ASVAD correspondiente a la WO-6056.

Como objetivos adicionales, se incluyen los siguientes:
- Realización del proceso de envejecimiento acelerado de juntas.
- Obtención del coeficiente de fuerza del muelle con la temperatura.
- Comprobación de los disparos en condiciones de accidente.

2. CAMPO DE APLICACIÓN.

Esta instrucción aplica a válvulas fabricadas por Ringo Válvulas S.L. en la obra WO-6056.

3. REFERENCIAS .

Código ASME Sección III, Subsección NB Edición 2015
ISO-5208-2008 (E)
ANSI / ASME QME -1- 2012

4. FORMATOS A SER USADOS.

El formato del Anexo I (F8-3-697) se usará como registro de los resultados de las pruebas. Se rellenaran y firmarán ambos formatos, en español e inglés.

Los datos de prueba requeridos tales como presión, pérdidas, duración de la prueba, etc, serán indicados en la hoja de pruebas antes de realizarse las pruebas. Los resultados reales serán registrados durante la realización de la prueba.

5. PERSONAL.

El personal responsable de la realización de la presente instrucción deberá estar cualificado según IN6-1-4: “Instrucción para la cualificación del personal de inspección, exámenes y pruebas”.

El personal responsable de la realización de la presente instrucción deberá cumplir con las normas de seguridad INMASS-1-7: “Normas de seguridad para prueba de válvulas”.

Precaución: Poner atención en el uso de EPI’s adecuados durante las pruebas.

Las pruebas serán presenciadas y validadas por una persona del Departamento de Garantía de la Calidad de Ringo Válvulas. Así mismo las pruebas pueden ser presenciadas y validadas por un inspector del cliente y/o por un inspector de una agencia autorizada por el cliente. Todos ellos firmaran en el registro de la prueba.

6. MATERIALES Y EQUIPOS.

6.1. Fluido.

El fluido de pruebas para esta prueba será nitrógeno industrial a temperatura ambiente. También es aceptable su realización con aire comprimido seco o sintético.

Se utilizará líquido buscafugas para la detección de las posibles fugas que pudieran darse.

6.2. Banco de pruebas.

Las pruebas se realizaran con la válvula ASVAD montada en posición vertical en la toma correspondiente del banco de pruebas diseñado especialmente para este fin.

Precaución: la válvula se instalará de forma que en ningún caso la descarga de la misma pueda causar daños tanto a personas como a la instalación.

6.3. Manómetros y transmisores de presión.

Los manómetros de prueba y/o los transmisores de presión estarán calibrados de acuerdo con ASME III, cláusula NB-6400.

Se seleccionarán de tal modo que la presión de prueba estará entre el 10% y el 90% del fondo de escala. La incertidumbre de los manómetros será menor de un 5% del rango. La de los transmisores será menor o igual al 1%.

Se requerirá de los siguientes equipos:

- Manómetro control de PD. Rango aconsejado 20/25 kg/cm2.
- Transmisor de presión. Rango aconsejado 20/25 kg/cm2.
- Manómetro presión aire de armado. Rango aconsejado 10/16 Bar.
- Bomba de vacío con manómetro de presión absoluta.

6.4. Registrador.

Se requiere de un registrador para registrar la rápida caída de presión tras el disparo de la válvula. Estará calibrado y dentro de su periodo de calibración.

Será capaz de adquirir muestras con una frecuencia de 50Hz o superior, y capacidad de visualizar un rango mínimo de 5 segundos de registro. Preferentemente con capacidades de disparo por trigger, pre y postrrigger, y el rango adecuado al transmisor de presión utilizado.

6.5. Termómetro.

Se utilizará un termómetro calibrado con una incertidumbre menor de ± 2ºC y capaz de medir hasta 175ºC. Puede utilizarse el del controlador de temperatura si cumple estos requisitos.

Prerrequisito: Antes de iniciar las pruebas comprobar que los equipos a utilizar se encuentran en su periodo de validez de calibración. Anotar su identificación en la hoja de registro.

7. PRUEBAS DE DISPARO.

Prerrequisito: Antes de iniciar las pruebas comprobar la integridad de la válvula, la ausencia de marcas o golpes, así como de cualquier otro daño que pueda afectar al funcionamiento de la misma.

Precaución: No manipular los elementos de la válvula o del sistema de prueba bajo presión. Si es necesario realizar algún reapriete, o reajuste de conexiones despresurizar completamente el sistema antes de proceder a ello.

Precaución: Una vez armada, la despresurización de la válvula por debajo de su punto de disparo, provoca el disparo de la válvula. Riesgo de proyecciones.

Precaución: Dado que la prueba se realiza con gas, proteger el entorno de la válvula mediante barreras físicas que eviten los riesgos de proyección de misiles que puedan derivarse de un fallo estructural en la misma o en el sistema de prueba.

La Presión de Disparo (PD) para todas las válvulas sujetas a esta instrucción es ajustable en un rango definido por las características del muelle instalado. Ir anotando en el formato los sucesivos valores obtenidos durante la ejecución de las pruebas.

Montar el sistema de pruebas según se indica en la figura 1 del anexo II.

7.1. PRUEBA DEL RANGO INFERIOR DE DISPARO.

7.1.1. Con la válvula montada sobre el banco de pruebas, desmontar la tapa superior para poder tener acceso a la salida superior del obturador.

7.1.2. Con la herramienta de ajuste de presión, destensar completamente el muelle girando en sentido antihorario el obturador hasta su tope. Esta posición se alcanza cuando los testigos antigiro <u>están a ras de la superficie superior</u> y coincide con el punto inferior de disparo de la válvula.

7.1.3. Montar la tapa superior, sin los tapones de cierre.

7.1.4. Cerrar el obturador de la válvula aplicando aire comprimido en la entrada de armado. Mantener dicha presión mientras la presión en la cámara inferior de la válvula sea inferior al 110% de la presión de disparo.

7.1.5. Presurizar la cámara inferior de la válvula con una presión inicial de al menos el 110% de su PD. Una vez a esta presión, despresurizar completamente la entrada de aire comprimido de armado.

7.1.6. Rociar las juntas susceptibles de fugas con el líquido busca fugas. Comprobar que no existen fugas apreciables, y solucionarlas si las hubiera.

7.1.7. Precaución: Riesgo de proyecciones al disparar la válvula. Disminuir lentamente la presión de la válvula hasta que esta dispare. Consultar en el registrador la presión existente en el momento del disparo. Anotar esta presión en el casillero de Punto Inferior de ajuste. Anotar la temperatura.

7.2. PRUEBA DEL RANGO SUPERIOR DE DISPARO.

7.2.1. Con la válvula montada sobre el banco de pruebas, desmontar la tapa superior para poder tener acceso a la salida superior del obturador.

7.2.2. Con la herramienta de ajuste de presión, tensar completamente el muelle girando en sentido horario el obturador hasta su tope. Esta posición se alcanza cuando los testigos antigiro están a ras del almenado del obturador y coincide con el punto superior de disparo de la válvula. Contar el número de vueltas aplicado para llegar a esta posición desde la anterior y apuntarlo en el formato. No sobrepasar este punto.

7.2.3. Montar la tapa superior, sin los tapones de cierre.

7.2.4. Cerrar el obturador de la válvula aplicando aire comprimido en la entrada de armado. Mantener dicha presión mientras la presión en la cámara inferior de la válvula sea inferior al 130% de la presión de disparo.

7.2.5. Presurizar la cámara inferior de la válvula con una presión inicial de al menos el 130% de su PD. Una vez a esta presión, despresurizar completamente la entrada de aire comprimido de armado.

7.2.6. Precaución: Riesgo de proyecciones al disparar la válvula. Disminuir lentamente la presión de la válvula hasta que esta dispare. Consultar en el registrador la presión existente en el momento del disparo. Anotar esta presión en el casillero de Punto Superior de ajuste. Anotar la temperatura.

7.3. PREPARACION PUEBAS DE DISPARO vs TEMPERATURA.

7.3.1. Desmontar la tapa superior para poder tener acceso a la salida superior del obturador.

7.3.2. Con la herramienta de ajuste de presión, destensar el muelle girando en sentido horario el obturador la mitad de las vueltas contabilizadas en la prueba anterior. Esto situará el punto de ajuste en su punto medio.

7.3.3. Montar la tapa superior, sin los tapones de cierre.

7.3.4. Montar el sistema calefactor y la protección térmica de la válvula según la figura 2 del anexo II. Esta prueba puede simultanearse con la del apartado 9, manteniendo la campana despresurizada.

7.4. PRUEBAS DE DISPARO A 40 ºC .

7.4.1. Programar una temperatura de 40ºC ±5ºC, y esperar a que la válvula alcance esa temperatura.

7.4.2. Armar la válvula aplicando aire comprimido en la entrada de armado. Mantener dicha presión mientras la presión en la cámara inferior de la válvula sea inferior al 110% de la presión de disparo.

7.4.3. Presurizar la cámara inferior de la válvula con una presión inicial de al menos el 110% de su PD. Una vez a esta presión, despresurizar completamente la entrada de aire comprimido de armado. Asegurarse del retorno del pistón de armado a su posición de reposo.

7.4.4. Precaución: Riesgo de proyecciones al disparar la válvula. Disminuir lentamente la presión de la válvula hasta que esta dispare. Consultar en el registrador la presión existente en el momento del disparo. Anotar esta presión en el casillero de presión de disparo a 40 ºC. Anotar la temperatura.

7.4.5. Repetir la prueba 5 veces anotando los resultados en el registro.

7.5. PRUEBAS DE DISPARO A 100ºC.

7.5.1. Arrancar el registro de la temperatura de la válvula y subir la temperatura de la válvula hasta alcanzar los 100ºC ±5ºC. Esperar al menos 10 min. para su estabilización. Esta prueba puede simultanearse con la del apartado 9, manteniendo la campana despresurizada.

7.5.2. Armar la válvula aplicando aire comprimido en la entrada de armado. Mantener dicha presión mientras la presión en la cámara inferior de la válvula sea inferior al 110% de la presión de disparo.

7.5.3. Presurizar la cámara inferior de la válvula con una presión inicial de al menos el 110% de su PD. Una vez a esta presión, despresurizar completamente la entrada de aire comprimido de armado. Asegurarse del retorno del pistón de armado a su posición de reposo.

7.5.4. Precaución: Riesgo de proyecciones al disparar la válvula.
Disminuir lentamente la presión de la válvula hasta que esta dispare. Consultar en el registrador la presión existente en el momento del disparo. . Anotar esta presión en el casillero de presión de disparo a 100 ºC. Anotar la temperatura.

7.5.5. Repetir la prueba 5 veces anotando los resultados en el registro.

7.5.6. En función del avance de las pruebas, puede realizarse el envejecimiento del apartado 8 antes de continuar el calentamiento.

7.6. PRUEBAS DE DISPARO A 140ºC.

7.6.1. Subir la temperatura de la válvula hasta los 140ºC ±5ºC. Esperar al menos 10 min. para su estabilización. Esta prueba puede simultanearse con la del apartado 9, manteniendo la campana despresurizada.

7.6.2. Cerrar el obturador de la válvula aplicando aire comprimido en la entrada de armado. Mantener dicha presión mientras la presión en la cámara inferior de la válvula sea inferior al 110% de la presión de disparo.

7.6.3. Presurizar la cámara inferior de la válvula con una presión inicial de al menos el 110% de su PD. Una vez a esta presión, despresurizar completamente la entrada de aire comprimido de armado.

7.6.4. Precaución: Riesgo de proyecciones al disparar la válvula. Riesgo térmico al manipular la válvula.
Disminuir lentamente la presión de la válvula hasta que esta dispare. Consultar en el registrador la presión existente en el momento del disparo. . Anotar esta presión en el casillero de presión de disparo a 140 ºC. Anotar la temperatura

7.6.5. Repetir la prueba 5 veces anotando los resultados en el registro. Tener en cuenta que en cada disparo, se produce un enfriamiento puntual de la válvula y puede ser necesario recuperar la temperatura antes de proceder con el siguiente disparo.

7.6.6. Una vez finalizados los 5 disparos, ajustar el control de temperatura a 120 ºC para proseguir con el envejecimiento acelerado por temperatura.

7.7. CALCULOS.

7.7.1. Calcular los valores medios de disparos y de temperaturas para cada una de las tres tandas de disparos y anotarlos en las casillas correspondientes.

7.7.2. Calcular las desviaciones máximas y mínimas (valor medio - valor obtenido) sobre la media obtenida para cada tanda de disparos. Apuntarlo en las casillas correspondientes.

7.7.3. Calcular las desviaciones porcentuales, dividiendo las desviaciones absolutas obtenidas por la PN y multiplicando por 100. Comprobar que dichas desviaciones se encuentran dentro del ±1% PN.

7.7.4. Calcular la deriva debida a la temperatura para el rango 40-100ºC (valor medio Tamb – Valor medio 100ºC) y para el rango 100ºC-140ºC (valor medio 100ºC – Valor medio 140ºC). Anotarlo en las casillas correspondientes.

7.7.5. Calcular el ratio (bar/ºC) dividiendo las derivas por los rangos de temperatura. Comprobar que se encuentra dentro de los criterios.

8. PROCESO DE ENVEJECIMIENTO ACELERADO.

8.1. Mantener la válvula a una temperatura mayor o igual a 120ºC durante al menos 15 horas acumuladas desde la fecha/hora anotada en el punto 7.5.2.

8.2. Sacar el registro de la evolución de la temperatura desde el inicio del calentamiento y guardarlo.

8.3. El tiempo utilizado durante las pruebas a 140ºC puede descontarse del periodo de envejecimiento acelerado.

8.4. En este punto puede optarse por comenzar con las pruebas de calificación ambiental con el procedimiento IN8-3-699. Se retomará la prueba tras el mismo. Dado que la prueba de calificación puede haber llevado a las juntas al límite de su vida operativa, puede considerarse su renovación antes de continuar la prueba.

9. PRUEBA DE DISPAROS EN MODO ACCIDENTE.

9.1. Esperar a que la válvula se encuentre a temperatura ambiente (20ºC a 30ºC). Retirar todos los tapones.

9.2. Realizar una serie de 5 disparos de la válvula en condiciones atmosféricas para determinar el punto de disparo atmosférico de la válvula. Anotar en el registro la presión de disparo, la temperatura y la presión externa (atmosférica).

9.3. Montar la campana y comprobar su estanqueidad. Ver figura 3.

9.4. Calentar la válvula a la temperatura indicada en la hoja de registro (±5ºC). Presurizar el interior de la campana a la presión indicada en la hoja de registro (±50 mBar).

9.5. Armar la válvula y realizar una serie de 5 disparos de la válvula en estas condiciones, vigilando cada vez las condiciones de presión en la campana y temperatura de la válvula. Apuntar en la hoja de registro los puntos de disparo, la temperatura y la presión en la campana.

9.6. Repetir los dos pasos anteriores para todas las combinaciones de presión/temperatura indicadas en la hoja de registro.

9.7. Calcular los valores medios de disparo para cada condición de presión/temperatura. Calcular su valor máximo y mínimo. Calcular la desviación máxima entre el máximo y el mínimo obtenidos y apuntarla.

9.8. Determinar si los valores obtenidos de disparo están dentro del margen permitido de variación de ± 1% PN (0,5 bar) del valor esperado. Anotarlo en la hoja de registro.

10. NORMALIZACION.

Si no se van a realizar más pruebas, retirar las conexiones de presión y desmontar la válvula del banco.

11. CRITERIOS DE ACEPTACION.

Los Criterios de aceptación para esta prueba son los siguientes:

Para la prueba del rango de ajuste:

- Con la válvula ajustada en su valor inferior, el disparo se produce en un valor ≤ a 13,1 Bar.
- Con la válvula ajustada en su valor superior, el disparo se produce en un valor ≥ a 18,9 Bar.

Para la prueba del Disparo vs Temperatura:

- Con la válvula ajustada al 50% de su rango de ajuste (aprox.), sus disparos se producen con una dispersión máxima del ± 1% PN (0,5 bar) sobre el valor medio de disparo para las temperaturas ensayadas.
- El ratio de deriva (absoluto) con la temperatura (RPDT) obtenido es menor o igual a 0,050 Bar / ºC en el rango de temperaturas entre 40ºC y 140ºC.

Para la fase de envejecimiento acelerado:

- La válvula ha sido sometida a una temperatura de 120ºC ±5ºC durante al menos 15 horas.

Para la prueba de disparos en modo accidente:

- Los valores de disparo obtenidos en las condiciones indicadas no se desvían más de ± 1% PN (0,5 bar) de los esperados.

12. ANEXOS

I. Hoja de datos FORMATO F8-3-697.
II. Configuración de las pruebas.

RINGO VALVULAS

TEST CERTIFICATE
TRIP RANGE & REPEATABILITY
ASVAD VALVE (WO-6056)

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

TEST PROCEDURE
IN8-3-697 Rev. 1

Sheet 1 of 4

CLIENT ASVAD INTL SL
Ref. CLIENT
SITE WO-6056
ITEM ASVAD-1
DATA 25/7/18

VALVE IDENTIFICATION	SERIAL	ASVAD-1	RANGE	13 Bar a 19 Bar
	MODEL		Nº TURNS	11 3/4
	NOMINAL PRESSURE PN	50 bar	CLOSING PRESSURE	MIN 4 Bar MAX 15 Bar
VISUAL INSPECTION	VALVE INTEGRITY OK?	[✓ YES ∧] NO ∇	DAMAGES OBSERVED?	YES ∧ [✓ NO ∇]

TRIP RANGE TEST 23/2/18

TEST	DESIRED VALUE	OBTAINED VALUE	DEVIATION	TEMPERATURE	CORRECT? YES/NO
TRIP LOWER POINT	13 Bar	12.38 bar	-0,62 bar	15 °C	YES
TRIP UPPER POINT	19 Bar	20,62 bar	+1,62 bar	16 °C	YES

TRIP vs TEMPERATURE TEST 25/7/18

TEST	TRIP PRESURE	AMBIENT TEMPERATURE	TRIP PRESURE	100 ºC TEMPERATURE	TRIP PRESURE	140 ºC TEMPERATURE
Middle point. Trip 1.	17.60 Bar.	41,1 ºC	17.21 Bar.	102,8 ºC	16,91 Bar.	143,8 ºC
Middle point. Trip 2.	17,52 Bar.	41,5 ºC	17,19 Bar.	102,4 ºC	16,91 Bar.	144,0 ºC
Middle point. Trip 3.	17,47 Bar.	41,3 ºC	17,18 Bar.	102,4 ºC	16,91 Bar.	144,3 ºC
Middle point. Trip 4.	17,45 Bar.	41,2 ºC	17,17 Bar.	102,4 ºC	16,91 Bar.	145,1 ºC
Middle point. Trip 5.	17,43 Bar.	41,1 ºC	17,19 Bar.	102,6 ºC	16,95 Bar.	145,4 ºC
AVERAGE VALUE	17,49 Bar.	41,2 ºC	17,19 Bar.	102,5 ºC	16,92 Bar.	144,5 ºC
ABSOLUTE DEVIATION	MIN 17,43	MAX 17,6	MIN 17,17	MAX 17,21	MIN 16,91	MAX 16,95
PORCENTUAL DEVIATION	DESIRED ≤ 1%	0,34 %	DESIRED ≤ 1%	0,08 %	DESIRED ≤ 1%	0,08 %
TEMPERATURE DRIFT	TIL 100ºC	0,30 Bar.	FROM 100ºC TO 140ºC	0,27 Bar.		
ABSOLUTE RATIO	0,005	Bar/ºC	0,006	Bar/ºC		
COMBINED RATIO	DESIRED	≤0,050 Bar/ºC	OBTAINED	0,0055	CORRECT Y/N	YES

RINGO Executed	RINGO Quality Insp.	**ASVAD INTL SL** Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com Client Inspector.	TÜV SÜD Iberia S.A.U. A-61870914 Authorized Inspector.

RINGO VALVULAS	**TEST CERTIFICATE** **TRIP RANGE & REPEATABILITY** **ASVAD VALVE** (WO-6056)

RINGO VÁLVULAS, S.L. **Polígono Empresarium** **Calle Romero nº 6** **50720 Zaragoza (España)**	TEST PROCEDURE IN8-3-697 Rev. 1	Sheet 3 of 4

ACCIDENT MODE TRIP TEST 25/7/18

CONDITION	PR. TRIP	TEMPERATURE	PR. CHAMBER	MEDIAN VALUES		
AMBIENT TEMPERAT.	18,66 Bar	31,3 ºC	2,0 Bar(abs)	TRIP PRES.	TEMPERATURE	CHAMBER PR.
	18,58 Bar	↓ ºC	↓ Bar(abs)	18,626 Bar	31,3 ºC	2,0 Bar(abs)
PRESSURE 2,00 Bar (abs)	18,69 Bar	ºC	Bar(abs)	REFERENCE V.		
	18,62 Bar	ºC	Bar(abs)			
	18,58 Bar	ºC	Bar(abs)			
TEMP. 40ºC	22,25 Bar	31,7 ºC	6,0 Bar(abs)	TRIP PRES.	TEMPERATURE	CHAMBER PR.
	22,22 Bar	↓ ºC	↓ Bar(abs)	22,25 Bar	31,7 ºC	6,0 Bar(abs)
PRESSURE 6,00 Bar (abs)	22,27 Bar	ºC	Bar(abs)	DESIRED V.	DIFERENCE	CORRECT Y/N
	22,27 Bar	ºC	Bar(abs)	Pd Ref + 4	3,62 Bar	
	22,25 Bar	ºC	Bar(abs)	DEVIATION	-0,38 Bar	YES
TEMP.= 40ºC	17,67 Bar	40,8 ºC	1,12 Bar(abs)	TRIP PRES.	TEMPERATURE	CHAMBER PR.
	17,63 Bar	40,8 ºC	↓ Bar(abs)	17,68 Bar	40,24 ºC	1,12 Bar(abs)
PRESSURE 1,12 Bar (abs)	17,68 Bar	40,8 ºC	Bar(abs)	DESIRED V.	DIFERENCE	CORRECT Y/N
	17,69 Bar	39,5 ºC	Bar(abs)	Pd Ref – 0,9	0,946 Bar	
	17,73 Bar	39,5 ºC	Bar(abs)	DEVIATION	0,046 Bar	YES
TEMP.= 100ºC	19,18 Bar	102,6 ºC	3,0 Bar(abs)	TRIP PRES.	TEMPERATURE	CHAMBER PR.
	19,21 Bar	102,8 ºC	↓ Bar(abs)	19,20 Bar	102,78 ºC	3.0 Bar(abs)
PRESSURE 2,99 Bar (abs)	19,23 Bar	102,7 ºC	Bar(abs)	DESIRED V.	DIFERENCE	CORRECT Y/N
	19,19 Bar	102,8 ºC	Bar(abs)	Pd Ref + 0,6	0,574 Bar	
	19,21 Bar	103,0 ºC	Bar(abs)		-0,026 Bar	YES
TEMP.= 140ºC	20,63 Bar	142,7 ºC	4,76 Bar(abs)	TRIP PRES.	TEMPERATURE	CHAMBER PR.
	20,65 Bar	142,8 ºC	↓ Bar(abs)	20,66 Bar	142,94 ºC	4,76 Bar(abs)
PRESSURE 4,76 Bar (abs)	20,67 Bar	143,0 ºC	Bar(abs)	DESIRED V.	DIFERENCE	CORRECT Y/N
	20,66 Bar	143,0 ºC	Bar(abs)	Pd Ref + 2,2	2,034 Bar	
	20,67 Bar	143,2 ºC	Bar(abs)	DEVIATION	-0,16 Bar	YES

RINGO Executed	RINGO Quality Insp.	**ASVAD INTL SL** Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com Client Inspector.	TÜV SÜD Iberia, S.A.U. Authorized Inspector.

RINGO
VALVULAS

TEST CERTIFICATE
TRIP RANGE & REPEATABILITY
ASVAD VALVE (WO-6056)

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

TEST PROCEDURE

IN8-3-697 Rev. 1

Sheet 4 of 4

ACELERATED AGING PROCESS

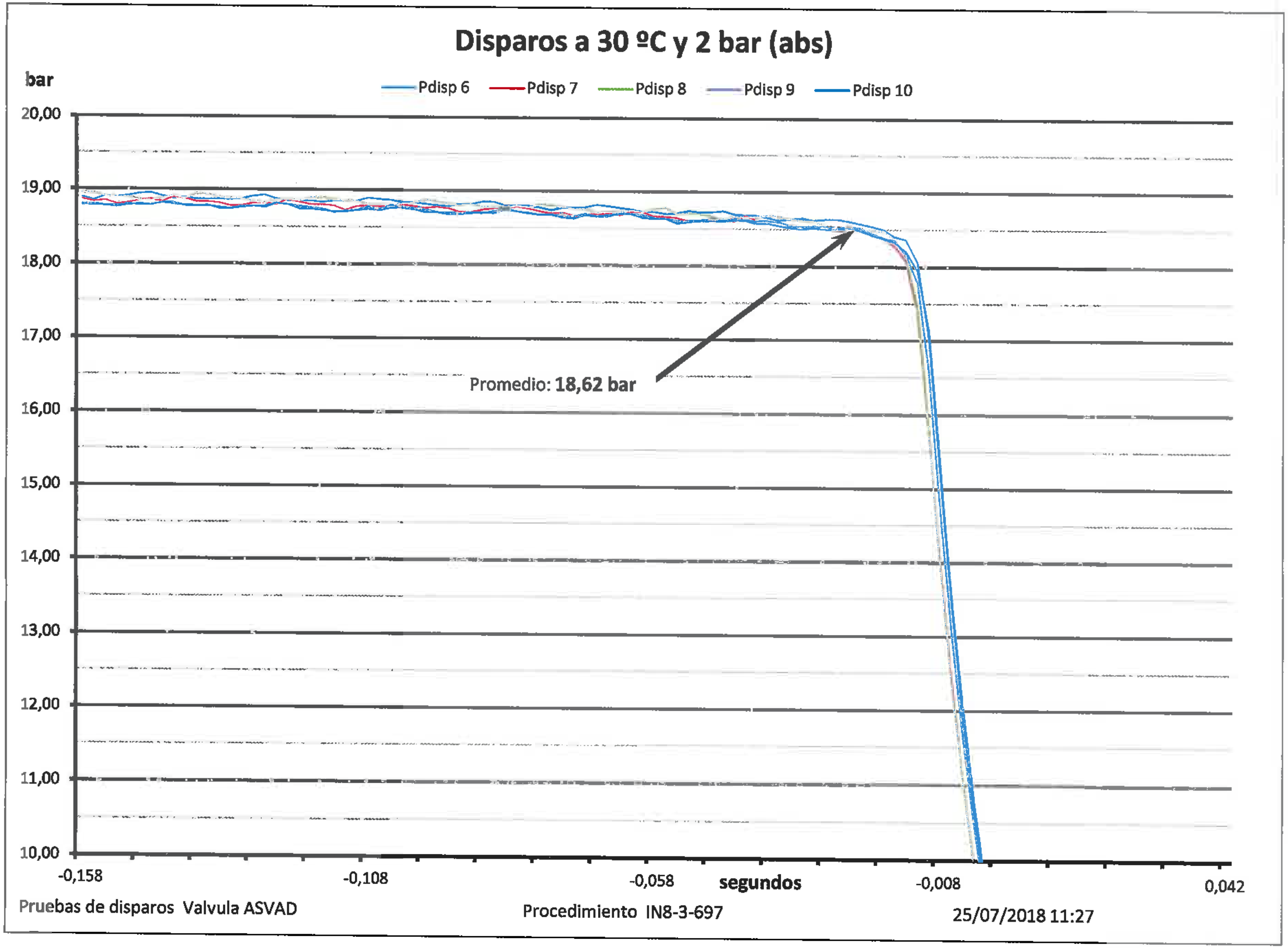
HEATING START	DATE: 13/6/18	HOUR: 15:06	AGEING TOTAL HOURS:
HEATING END	DATE: 14/6/18	HOUR: 12:30	21,4 h

MEASUREMENT AND TEST EQUIPMENT

DESCRIPTION	ID. NUMBER	CALIBRATION DUE DATE	DESCRIPTION	ID. NUMBER	CALIBRATION DUE DATE
REGISTER	2106310	7/5/18	MANOMETER 0-10 bar	RU-551	JUL/19
PRES. TRANS. 25 bar	2188012	1/2/19	MANOMETER 0-100 bar	RV-518	ABR/19
PRES. TRANS 10 bar	2188015	1/2/19	MANOMETER 0-2 bar abs	2153010	9/5/19
TEMP. TRANS 0-200°C	2188013	2/2/19	MANOMETER 0-40 bar	RU-229	DIC/18
CONTROLLER 0-700°C	2186069	2/2/19			

Comments:

		ASVAD INTL SL Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com	TÜV SÜD Iberia, S.A.U.
RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.

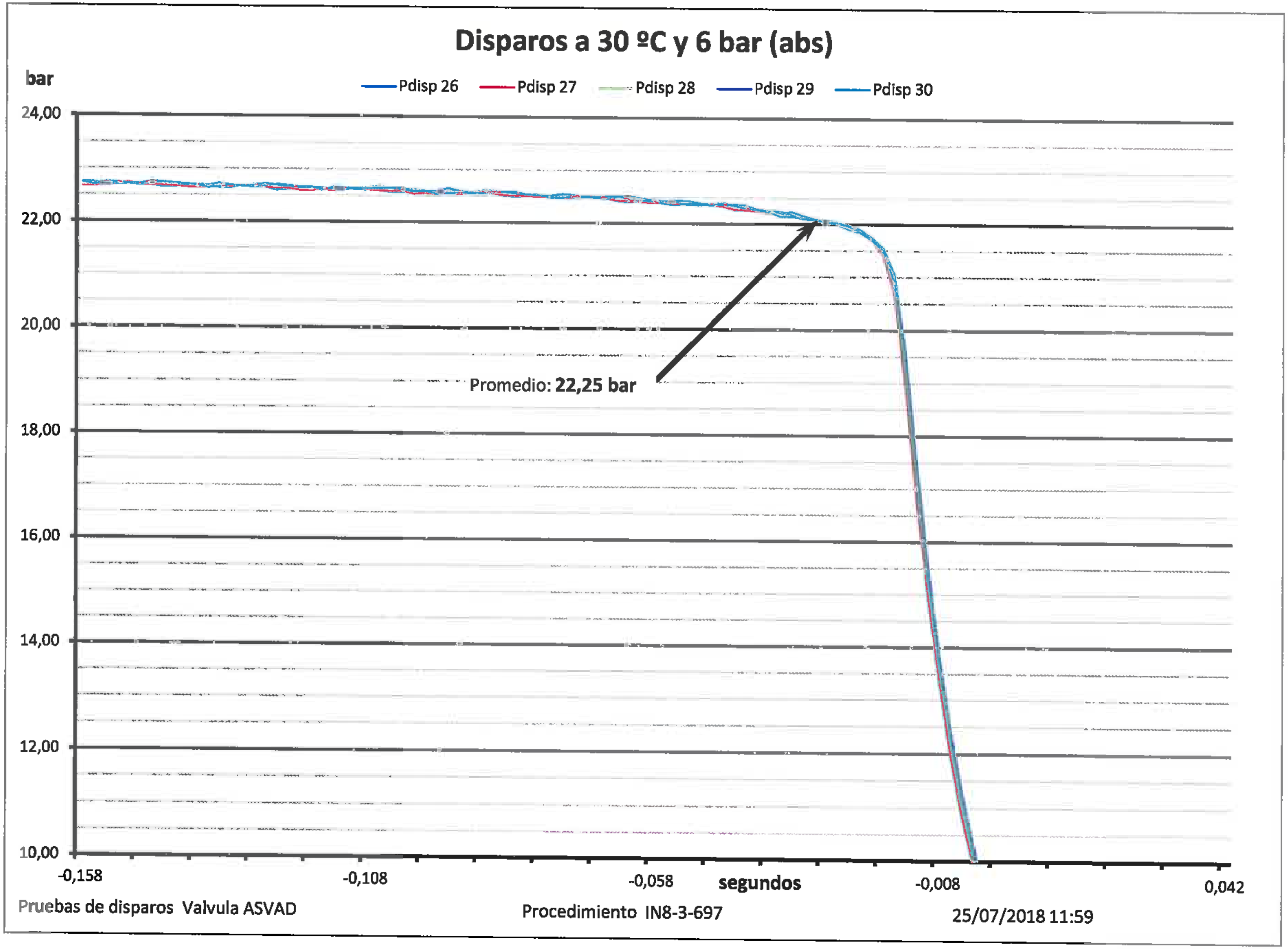


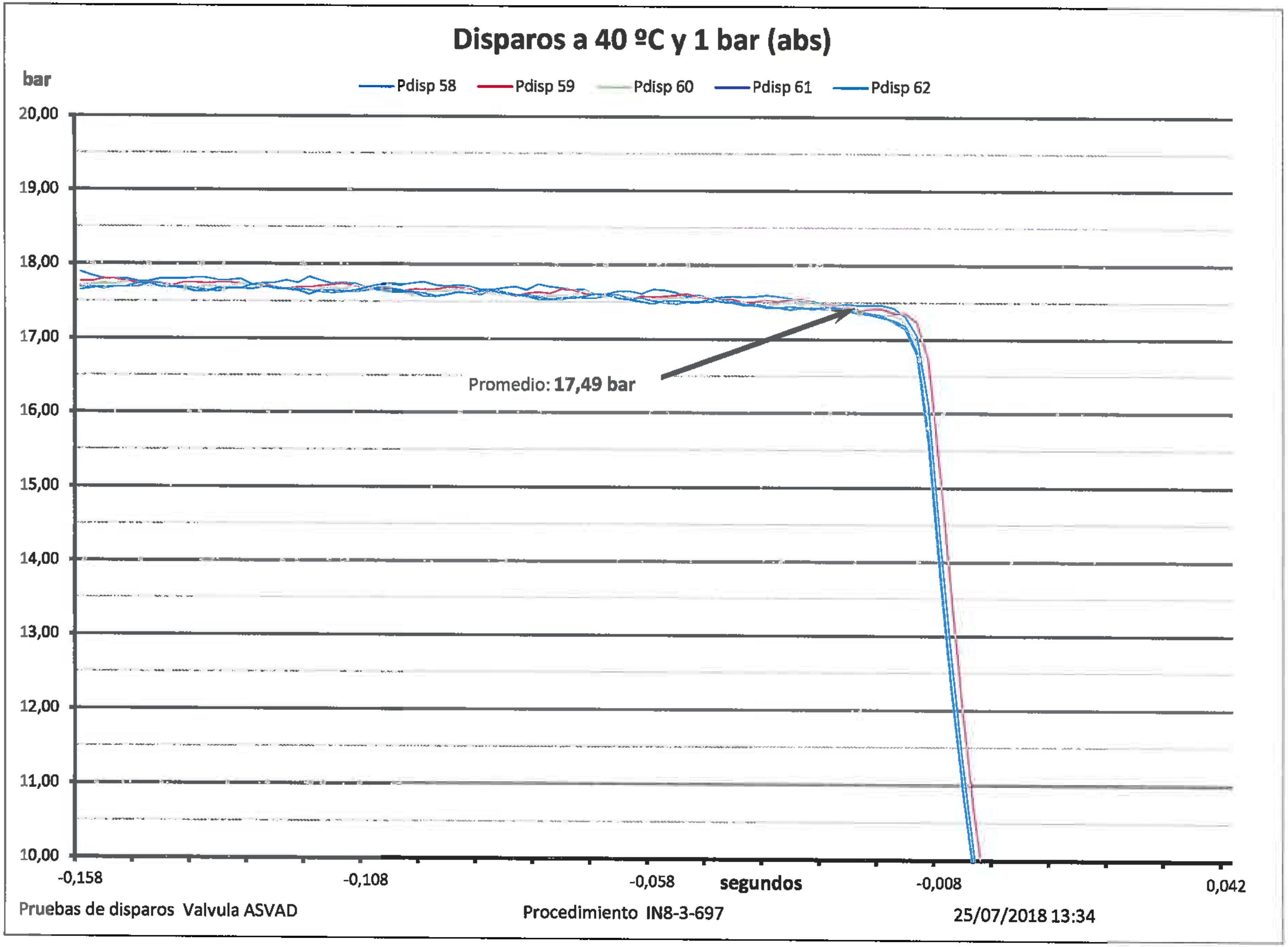
Disparos a 30 ºC y 2 bar (abs)

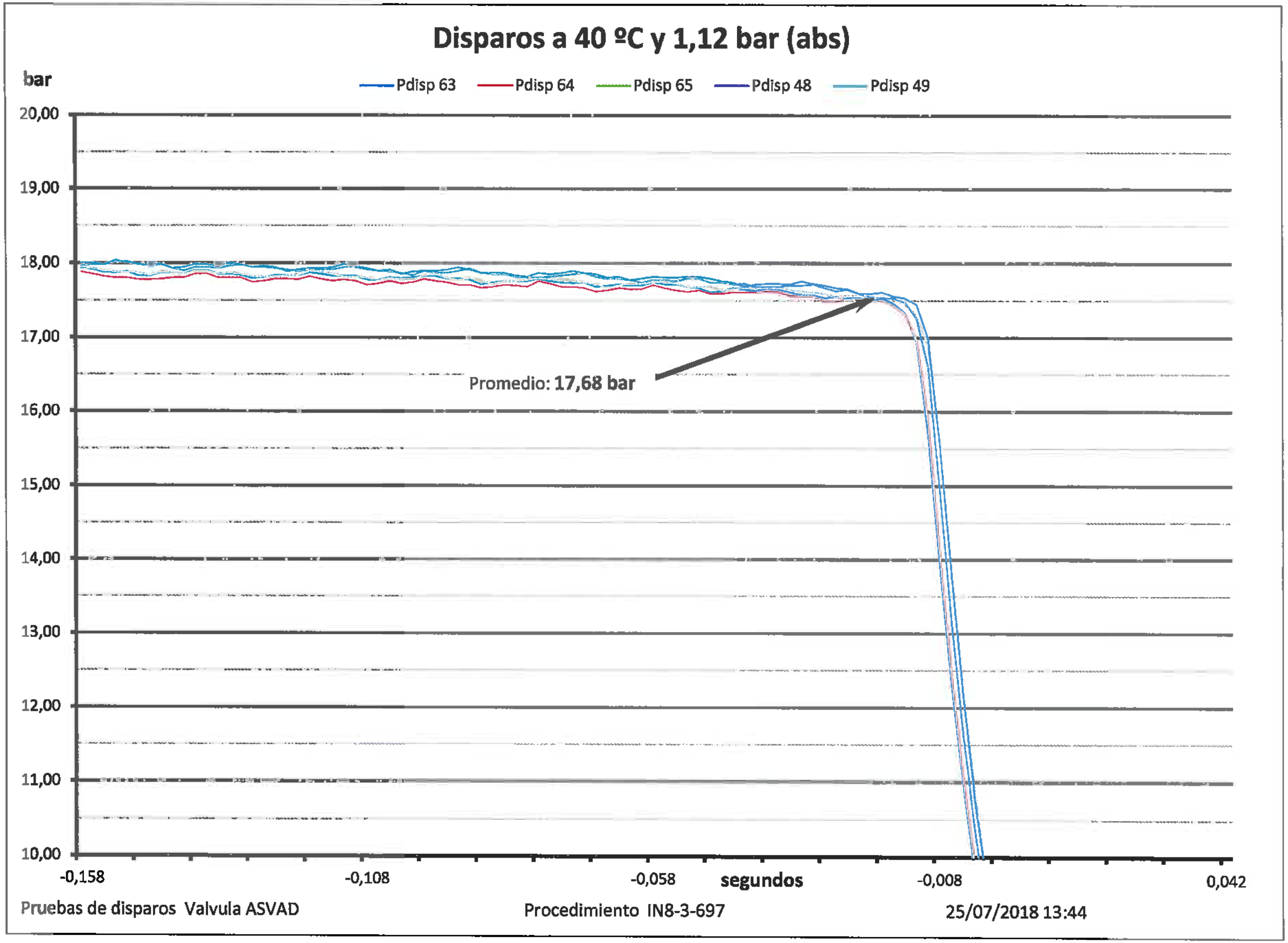
Pruebas de disparos Valvula ASVAD

Procedimiento IN8-3-697

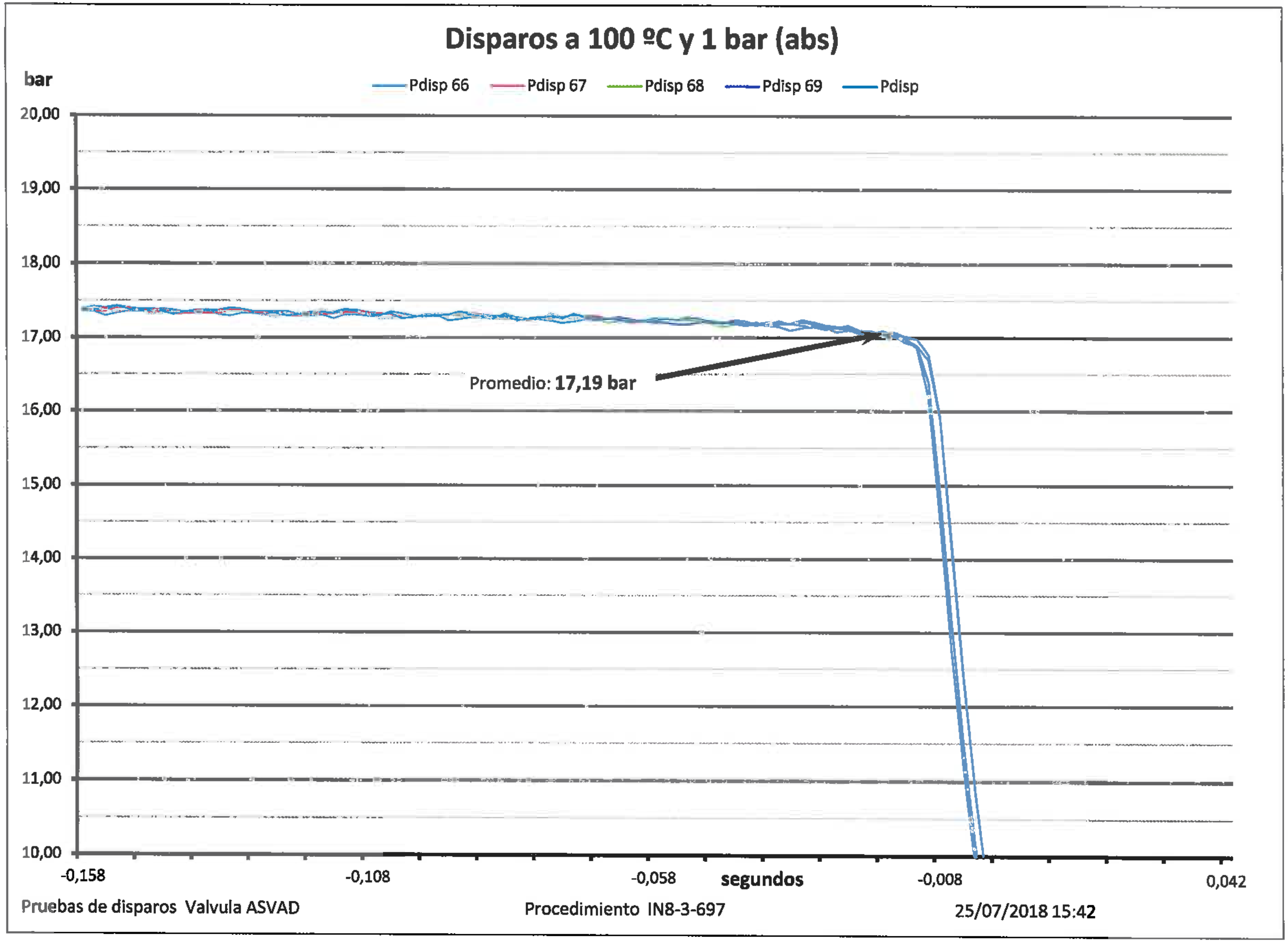
25/07/2018 11:27

Disparos a 30 ºC y 6 bar (abs)
bar
Pdisp 26
Pdisp 27
Pdisp 28
Pdisp 29
Pdisp 30
24,00
22,00
20,00
18,00
16,00
14,00
12,00
10,00
Promedio: 22,25 bar
-0,158
-0,108
-0,058
segundos
-0,008
0,042
Pruebas de disparos Valvula ASVAD
Procedimiento IN8-3-697
25/07/2018 11:59

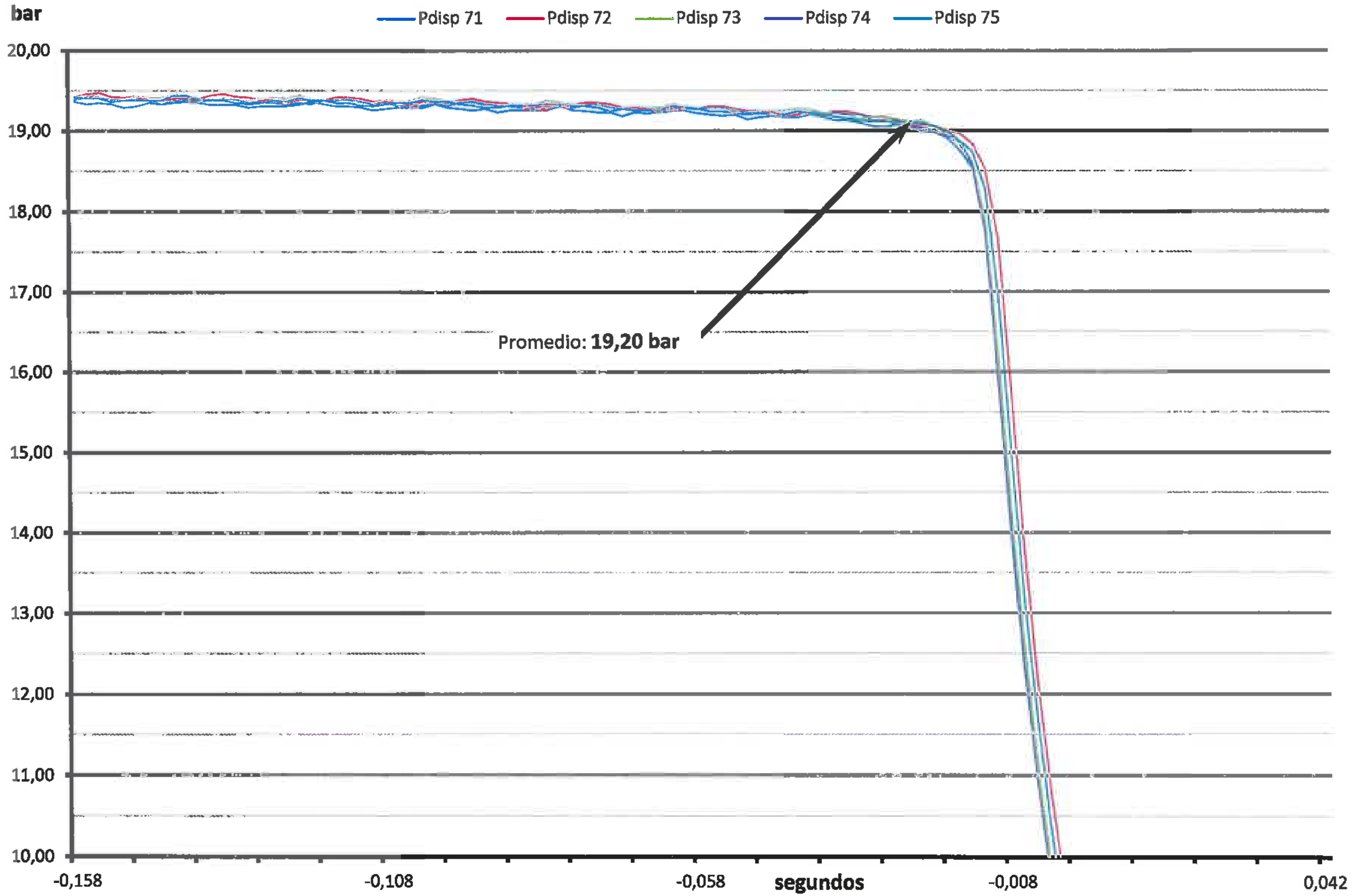

Disparos a 40 ºC y 1 bar (abs)
bar
Pdisp 58
Pdisp 59
Pdisp 60
Pdisp 61
Pdisp 62
20,00
19,00
18,00
17,00
16,00
15,00
14,00
13,00
12,00
11,00
10,00
Promedio: 17,49 bar
-0,158
-0,108
-0,058
segundos
-0,008
0,042
Pruebas de disparos Valvula ASVAD
Procedimiento IN8-3-697
25/07/2018 13:34



Disparos a 40 ºC y 1,12 bar (abs)


Disparos a 100 ºC y 1 bar (abs)
bar
Pdisp 66
Pdisp 67
Pdisp 68
Pdisp 69
Pdisp
20,00
19,00
18,00
17,00
16,00
15,00
14,00
13,00
12,00
11,00
10,00
Promedio: 17,19 bar
-0,158
-0,108
-0,058
segundos
-0,008
0,042
Pruebas de disparos Valvula ASVAD
Procedimiento IN8-3-697
25/07/2018 15:42

Disparos a 100 ºC y 3 bar (abs)

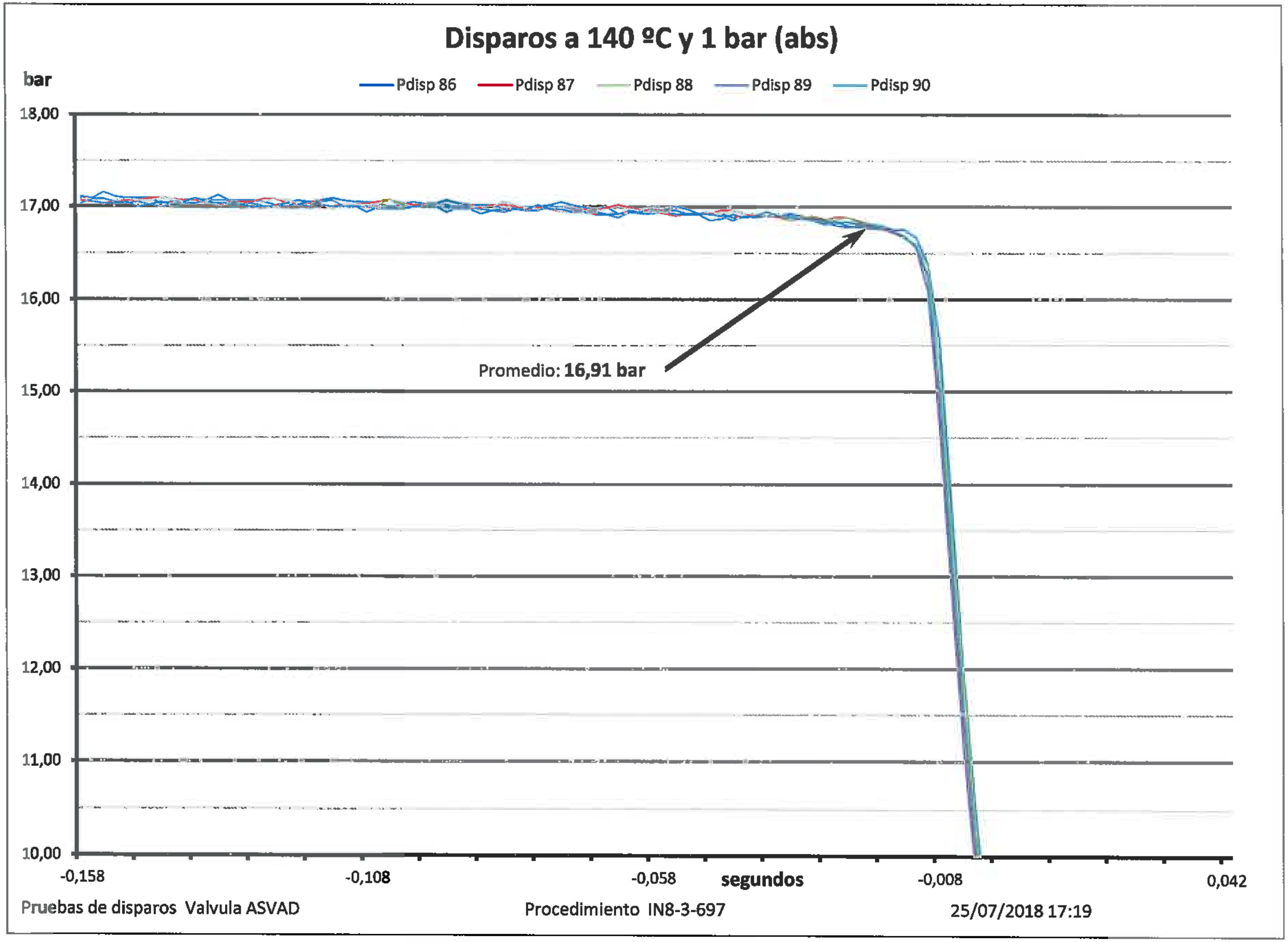


Promedio: **19,20 bar**

Pruebas de disparos Valvula ASVAD

Procedimiento IN8-3-697

25/07/2018 15:48



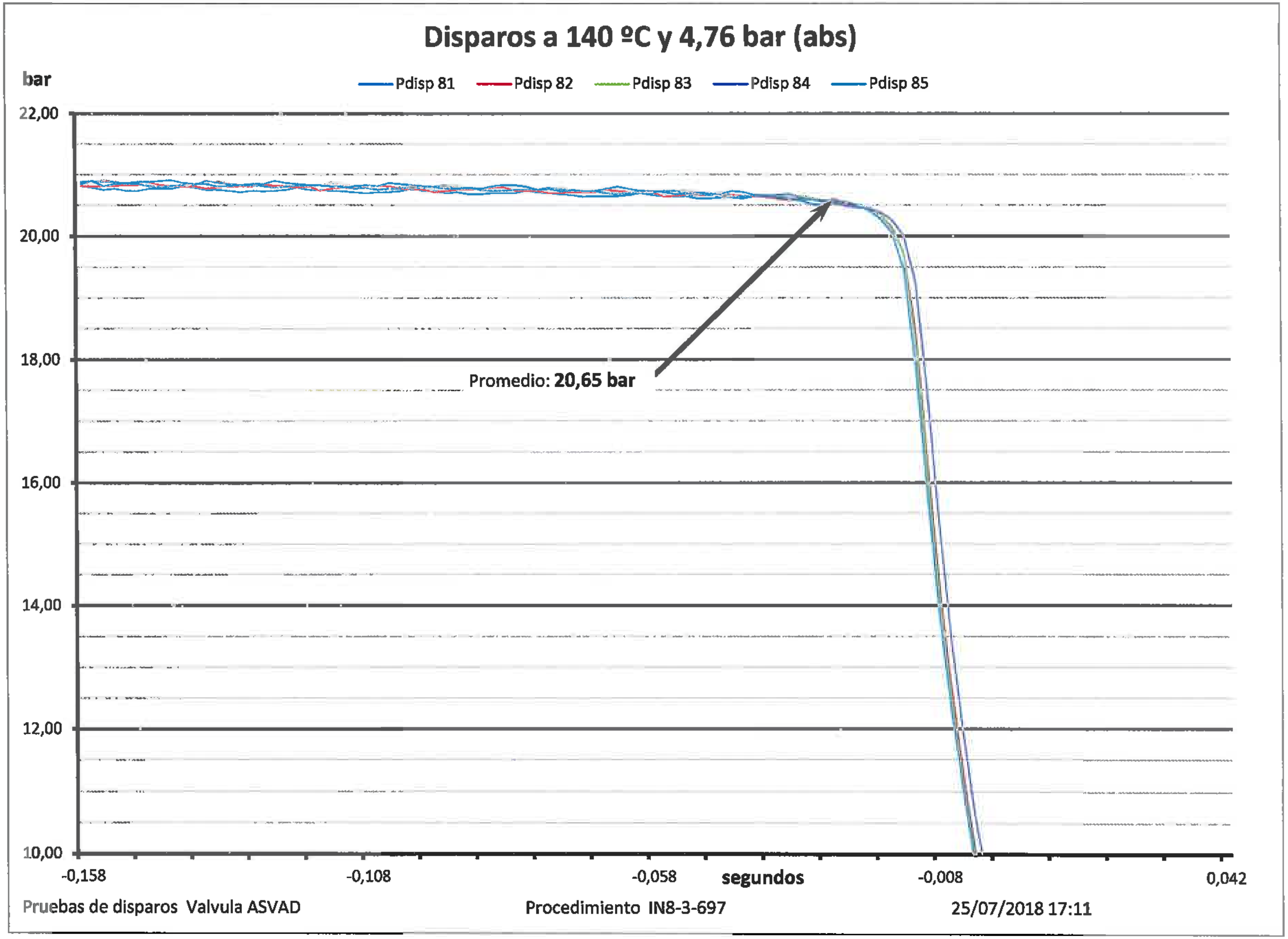
Disparos a 140 ºC y 1 bar (abs)

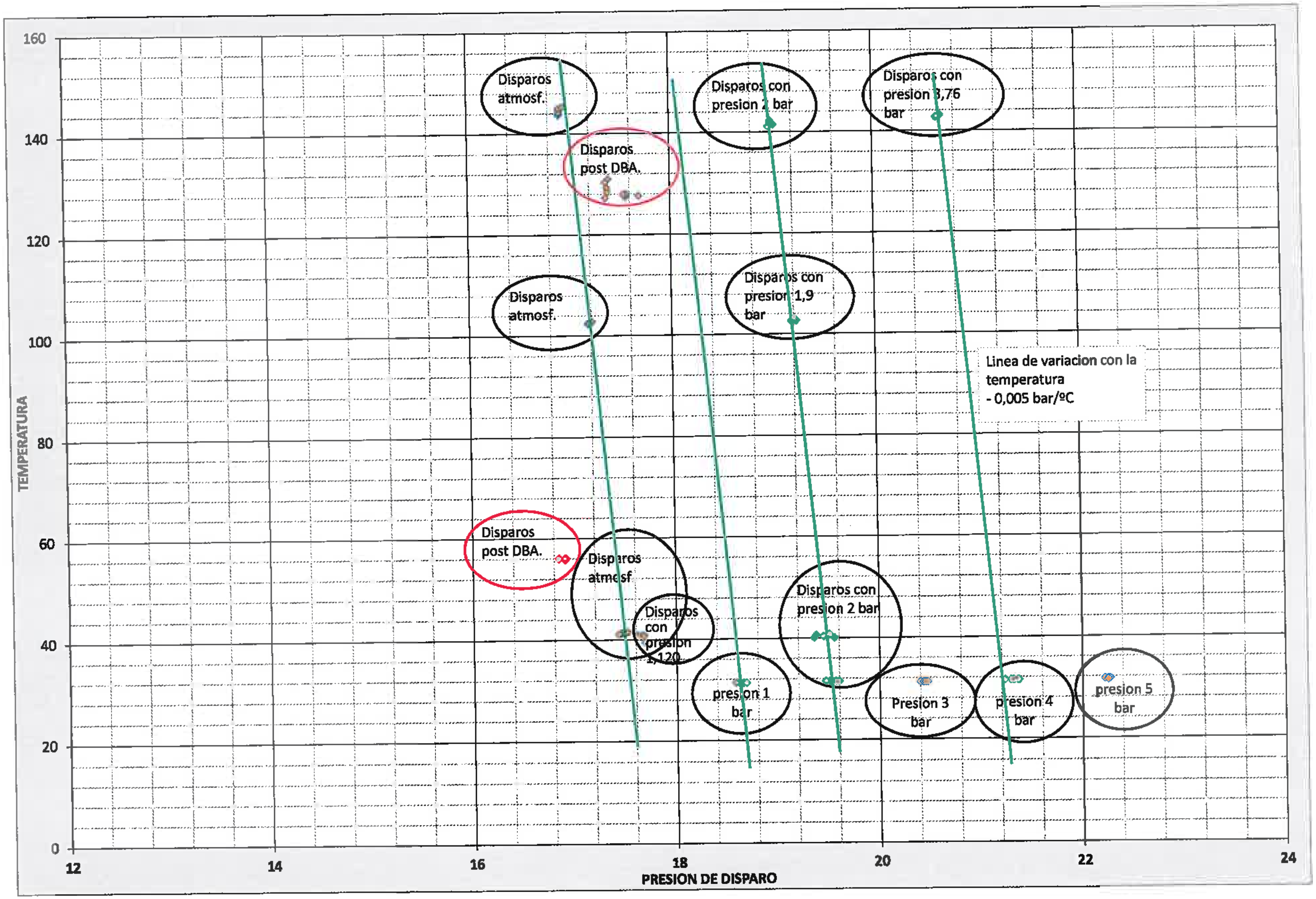
Promedio: **16,91 bar**

Pruebas de disparos Valvula ASVAD

Procedimiento IN8-3-697

25/07/2018 17:19


Disparos a 140 ºC y 4,76 bar (abs)
bar
Pdisp 81
Pdisp 82
Pdisp 83
Pdisp 84
Pdisp 85
22,00
20,00
18,00
16,00
14,00
12,00
10,00
Promedio: 20,65 bar
-0,158
-0,108
-0,058
segundos
-0,008
0,042
Pruebas de disparos Valvula ASVAD
Procedimiento IN8-3-697
25/07/2018 17:11

160
140
120
100
80
60
40
20
0
TEMPERATURA
12
14
16
18
20
22
24
PRESION DE DISPARO
Disparos atmosf.
Disparos post DBA.
Disparos atmosf.
Disparos con presion 2 bar
Disparos con presion 3,76 bar
Disparos con presion 1,9 bar
Linea de variacion con la temperatura - 0,005 bar/ºC
Disparos post DBA.
Disparos atmosf
Disparos con presion 1,120
presion 1 bar
Disparos con presion 2 bar
Presion 3 bar
presion 4 bar
presion 5 bar

CONFIGURACION DE LAS PRUEBAS

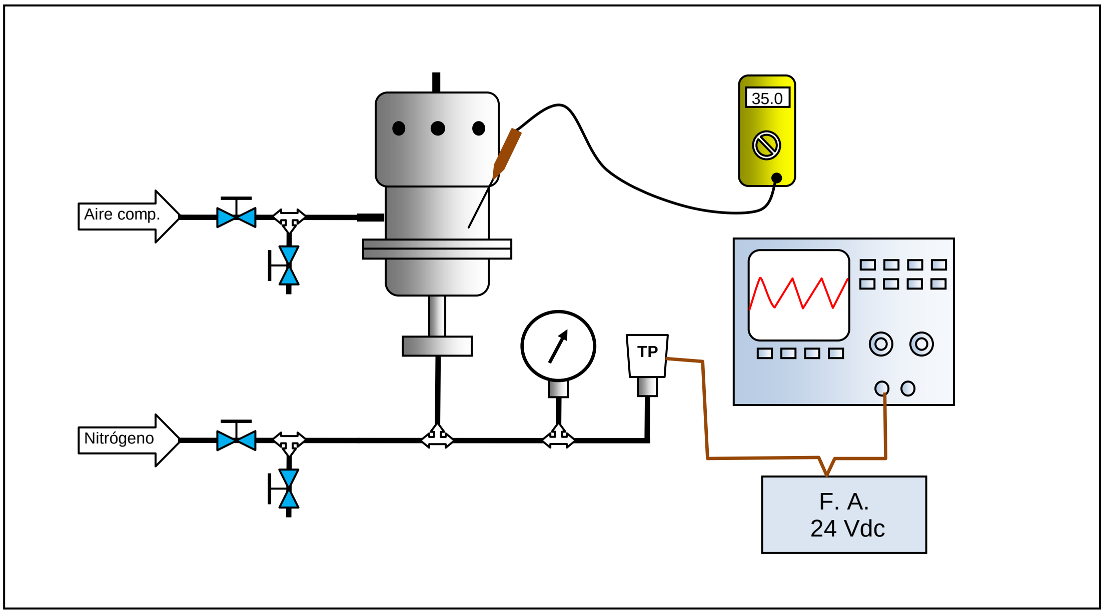


Figura 1. Prueba del rango de ajuste

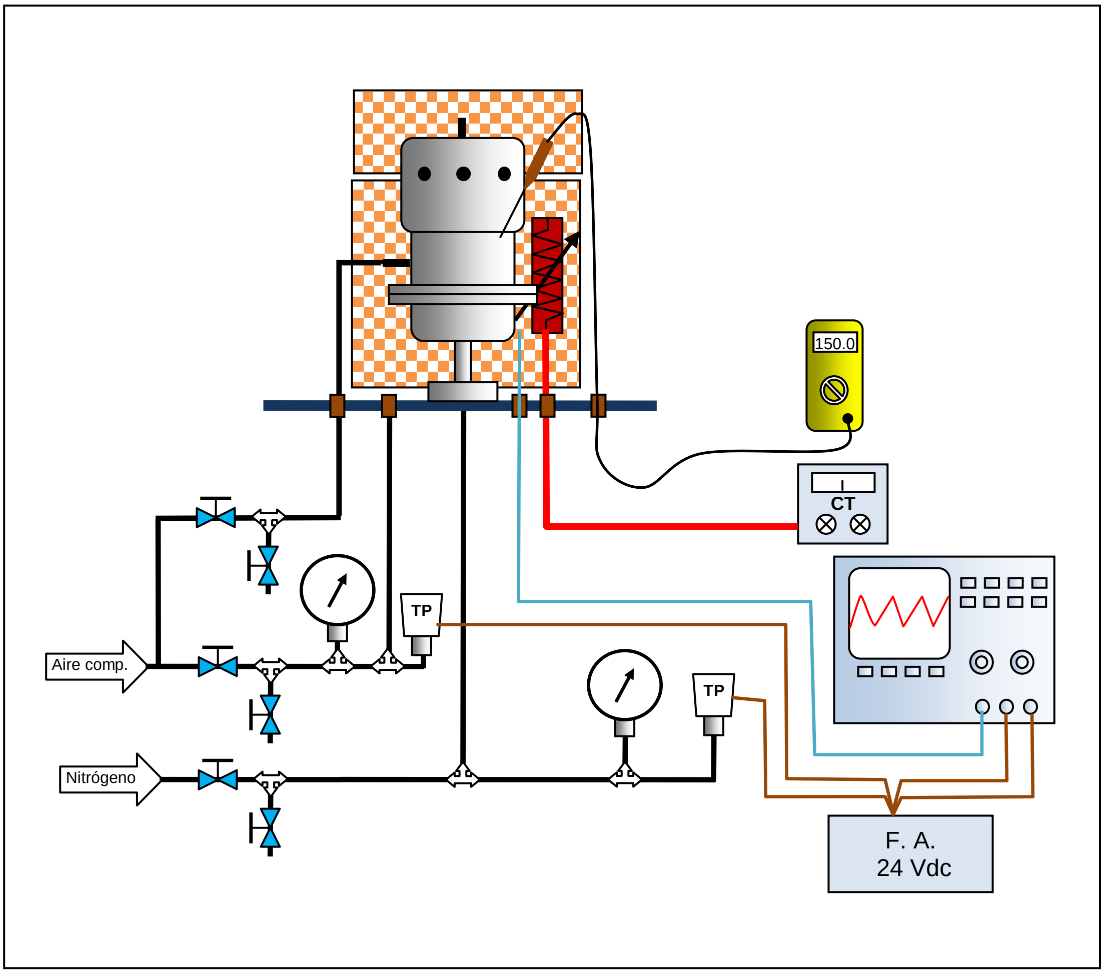


Figura 2. Prueba de Disparos vs Temperatura.

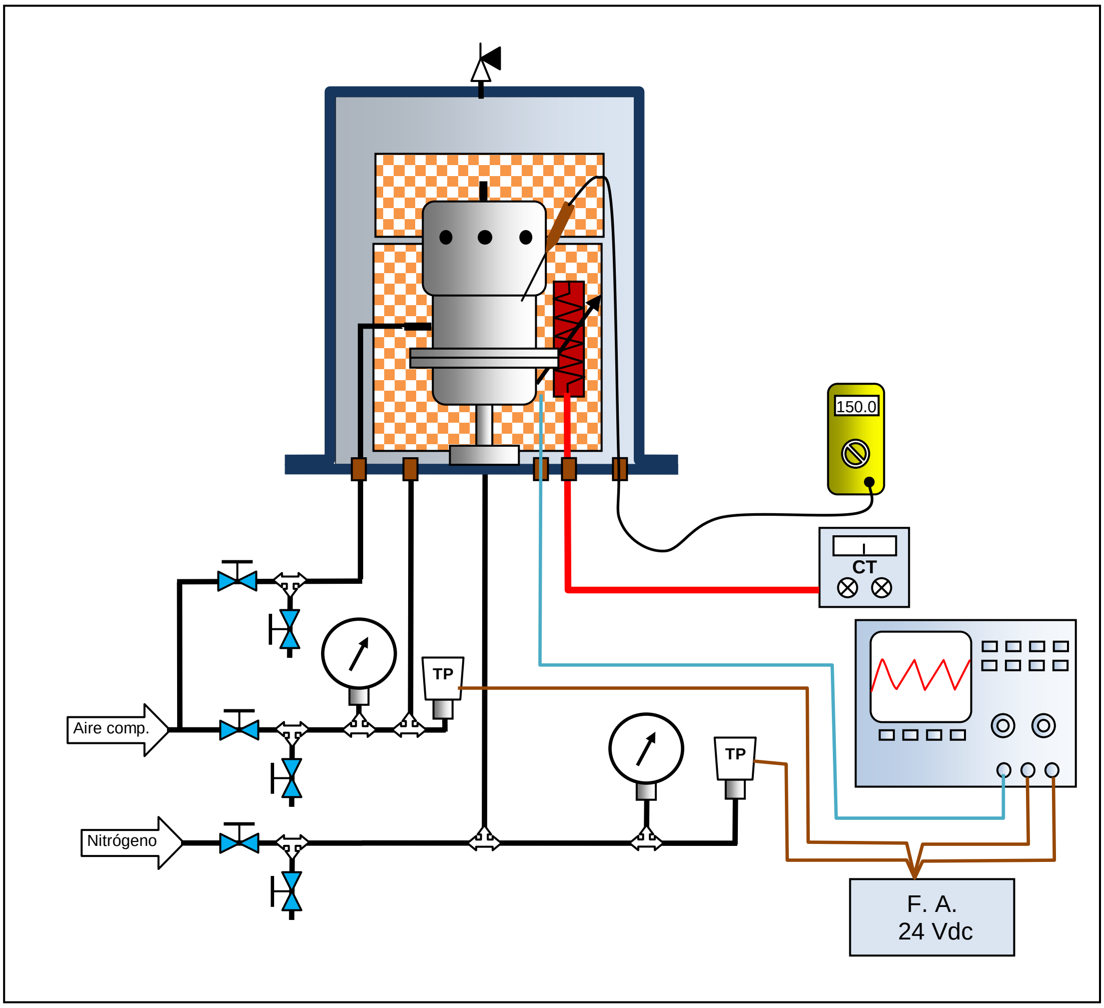


Figura 3. Prueba de Disparos modo accidente.

Revisado: RESPONSABLE CALIDAD	**Aprobado:** RESPONSABLE OPERACIONES

0. HISTORIAL DE REVISIONES.

Rev.	**Fecha/*Date***	**Asunto/*Subject***	**Aprobado/*Approved***	**Revisado/*Revised***
0	04/01/2018	Emisión Inicial	JMGM	MO
1	10/06/2018	*Revisión pruebas*	JMGM	MO

1. OBJETO.

Este documento tiene por objeto definir las pautas necesarias para llevar a cabo las pruebas que demuestren la robustez de la válvula ASVAD ante las circunstancias ambientales externas definidas para un accidente DBA según la IEE-323-1974.

2. CAMPO DE APLICACIÓN.

Esta instrucción aplica a las válvulas fabricadas por Ringo Válvulas S.L. en la obra WO-6056.

3. REFERENCIAS .

Código ASME Sección III, Subsección NB Edición 2015
ISO-5208-2008 (E)
ANSI / ASME QME -1- 2012

4. FORMATOS A SER USADOS.

El formato del Anexo I (F8-3-699) se usará como registro de los resultados de las pruebas. Se rellenaran y firmarán ambos formatos, en español e inglés.

Los datos de prueba requeridos tales como presión, pérdidas, duración de la prueba, etc, serán indicados en la hoja de pruebas antes de realizarse las pruebas. Los resultados reales serán registrados durante la realización de la prueba.

5. PERSONAL.

El personal responsable de la realización de la presente instrucción deberá estar cualificado según IN6-1-4: “Instrucción para la cualificación del personal de inspección, exámenes y pruebas”.

El personal responsable de la realización de la presente instrucción deberá cumplir con las normas de seguridad INMASS-1-7: “Normas de seguridad para prueba de válvulas”.

Precaución: Poner atención en el uso de EPI’s adecuados durante las pruebas.

Las pruebas serán presenciadas y validadas por una persona del Departamento de Garantía de la Calidad de Ringo Válvulas. Así mismo las pruebas pueden ser presenciadas y validadas por un inspector del cliente y/o por un inspector de una agencia autorizada por el cliente.

6. MATERIALES Y EQUIPOS.

6.1. Fluido.

El fluido de pruebas para esta prueba será nitrógeno industrial a temperatura ambiente. También es aceptable su realización con aire comprimido seco o sintético.

Se utilizará líquido buscafugas para la detección de las posibles fugas que pudieran darse.

6.2. Banco de pruebas.

Las pruebas se realizaran con la válvula ASVAD montada en posición vertical en la toma correspondiente del banco de pruebas diseñado especialmente para este fin.

Precaución: la válvula se instalará de forma que en ningún caso la descarga de la misma pueda causar daños tanto a personas como a la instalación.

6.3. Manómetros y transmisores de presión.

Los manómetros de prueba y/o los transmisores de presión estarán calibrados de acuerdo con ASME III, cláusula NB-6400.
Se seleccionarán de tal modo que la presión de prueba estará entre el 10% y el 90% del fondo de escala. La incertidumbre de los manómetros será menor de un 5% del rango. La de los transmisores será menor o igual al 1%.

Se requerirá de los siguientes equipos:

- Manómetro control de PD. Rango aconsejado 20/25 kg/cm2.
- Transmisor de presión PD. Rango aconsejado 20/25 kg/cm2.
- Manómetro/Transmisor presión campana. Rango aconsejado 10 Bar.

6.4. Registrador.

Se requiere de un registrador calibrado para registrar la rápida caída de presión tras el disparo de la válvula. También se utilizará para registrar la presión y temperatura de la cámara.

Será capaz de adquirir muestras con una frecuencia de 50Hz o superior, y capacidad de visualizar un rango mínimo de 5 segundos de registro. Para el registro de periodos de más de 1 día, la frecuencia de adquisición puede bajar hasta 1 toma cada 5 o 10 min. Preferentemente con capacidades de disparo por trigger, pre y postrigger, y el rango adecuado al transmisor de presión utilizado.

6.5. Termómetro.

Se utilizará un termómetro calibrado con una incertidumbre menor de ± 2ºC y capaz de medir hasta 200ºC. Puede utilizarse el del controlador de temperatura si cumple estos requisitos. Utilizar una sonda adicional para el registro de la temperatura.

Prerrequisito: Antes de iniciar las pruebas comprobar que los equipos a utilizar se encuentran en su periodo de validez de calibración. Anotar su identificación en la hoja de registro.

7. PRUEBA DE CALIFICACION AMBIENTAL.

Prerrequisito: Antes de iniciar las pruebas comprobar la integridad de la válvula, la ausencia de marcas o golpes, así como de cualquier otro daño que pueda afectar al funcionamiento de la misma.

Precaución: No manipular los elementos de la válvula o del sistema de prueba bajo presión. Si es necesario realizar algún reapriete, o reajuste de conexiones despresurizar completamente el sistema antes de proceder a ello.

Precaución: Dado que la prueba se realiza con gas, proteger el entorno de la válvula mediante barreras físicas que eviten los riesgos de proyección de misiles que puedan derivarse de un fallo estructural en la misma o en el sistema de prueba. Minimizar la parte de la instalación sometida a presión.

La Presión Externa Máxima (PEXM) que la válvula debe de soportar sin afectación es la presión máxima que se estima que pueda producirse en el edificio de contención tras un accidente LOCA o HELB, y asciende a 70 psi (5 Bar). La prueba también da cobertura al perfil de temperatura máxima esperada, superando los 157ºC.

Ir anotando en el formato los sucesivos valores obtenidos durante la ejecución de las pruebas.

7.1. Condiciones de partida:

Si no lo está ya de una prueba anterior, montar el sistema de pruebas según se indica en la figura 1 del anexo II, pero sin colocar todavía la campana hermética.

La válvula deberá estar ajustada al 50%. Ajustarla aproximadamente a ese valor si no lo estuviera.

Montar la tapa superior de la válvula. No instalar los tapones.

Comprobar abierta la toma de aire del pistón de apertura.

7.2. Prueba preliminar de disparos:

Realizar una serie de 5 disparos en condiciones similares a la DBA (120ºC ± 5ºC y 2,06 bar (abs)) para determinar el punto de disparo al que queda ajustada la válvula. Apuntar los resultados, la temperatura y la presión ambiental en la hoja de registro. Calcular la media obtenida.

7.3. Preparación y armado:

Armar la válvula y presurizar la cámara de presión con una presión de al menos el 110% de su PN. Mantener esa presión durante todo el proceso de calificación hasta el disparo del apartado 7.6.

Una vez armada y presurizada, asegurarse de que el pistón de armado queda despresurizado dejando abierta su válvula de alivio.

Montar la campana hermética y atornillarla para darle estanqueidad. Subir y mantener la presión en el interior de la campana hasta la presión de prueba (>5,32 Bar).

7.4. Simulación accidente DBA:

Comenzar el registro a baja velocidad de las variables ambientales de la cámara y de la presión en la cámara de la válvula.

Ajustar el controlador de temperatura a 160 ºC. Esperar a que la temperatura de la válvula suba hasta la temperatura de accidente DBA (>157 ºC).

En esas circunstancias, anotar la fecha/hora. Este valor será el tiempo T0 de comienzo de la prueba de calificación ambiental.

Mantener estas condiciones, durante al menos 10 h desde T0 registrando la presión en la cámara inferior de la válvula, la presión interior en la campana de prueba y la temperatura de la válvula.

Tras las 10 h a 160ºC, disminuir el setpoint de temperatura a 120ºC y esperar al menos 86 h registrando la presión en la cámara inferior de la válvula, la presión interior en la campana de prueba y la temperatura de la válvula.

Guardar el registro de baja velocidad de las 96h de la prueba ambiental y preparar el registrador en alta velocidad para registrar el disparo de la válvula

7.5. Disparo post-accidente DBA:

Una vez transcurridas las 96 h desde T0, proceder a reducir la presión en la campana a un valor de 2,06 bar (abs) ± 0,1 bar.

Asegurarse de que el registrador está preparado para grabar el disparo.

Precaución: Riesgo de presurización de la campana de prueba.

Cerrar la válvula de entrada de presión a la cámara inferior. Con la válvula de alivio, disminuir lentamente la presión de la cámara inferior de la válvula hasta que esta dispare. Anotar la fecha/hora en el apartado Td.

Consultar en el registrador la presión existente en el momento del disparo. Anotar esta presión en el casillero de Punto de Disparo a 120ºC y 2 Bar.

7.6. Disparo post-accidente en condiciones ambientales:

Desconectar el equipo de calentamiento de la válvula y dejar que esta se enfríe de manera natural.

Despresurizar lentamente la campana de pruebas hasta la presión atmosférica. Desmontar la campana. Esperar a que la válvula vuelva a estar aproximadamente a la temperatura ambiente.

Armar la válvula y presurizar la cámara de presión con una presión de al menos el 110% de su PD. Retirar los tapones si no lo estuvieran.

Una vez armada y presurizada, asegurarse de que el pistón de armado queda despresurizado dejando abierta su válvula de alivio.

Precaución: Riesgo de proyecciones al disparar la válvula. Cerrar la válvula de entrada de presión a la cámara inferior. Con la válvula de alivio, disminuir lentamente la presión de la cámara inferior de la válvula hasta que esta dispare.

Consultar en el registrador la presión existente en el momento del disparo. Anotar esta presión en el casillero de Punto de Disparo post DBA.

8. NORMALIZACION.

Si no se van a realizar más pruebas, retirar las conexiones de presión y desmontar la válvula del banco.

9. CRITERIOS DE ACEPTACION.

Los Criterios de aceptación para esta prueba son los siguientes:

- Con la campana presurizada a 2,06 bar (abs) ± 0,1 bar y tras la aplicación del perfil de temperatura de DBA especificado (10h a 160ºC + 86h a 120ºC), la válvula dispara a la presión especificada (±1 bar).
- Tras superar las condiciones de accidente DBA, la válvula dispara a la presión especificada (±1 bar) en las condiciones iniciales (presión y temperatura ambiental).

10. ANEXOS

I. Hoja de datos FORMATO F8-3-699.
II. Configuración de las pruebas.

RINGO VALVULAS	**TEST CERTIFICATE** **AMBIENTAL CALIFICATION** **ASVAD VALVE** (WO-6056)

RINGO VÁLVULAS, S.L. **Polígono Empresarium** **Calle Romero nº 6** **50720 Zaragoza (España)**	TEST PROCEDURE IN8-3-699 Rev. 1	Sheet 1 of 2

CLIENT ASVAD Ref. CLIENT	SITE WO-6056 ITEM ASVAD-1	DATA 25/2/18

VALVE IDENTIFICATION	SERIAL	ASVAD-1	NOMINAL PRESSURE PN	50
	MODEL		TRIP PRESSURE PD	16,5
VISUAL INSPECTION	VALVE INTEGRITY OK? [✓ YES ∧] NO ∇		OBSERVED DAMAGES? YES ∧ [✓ NO ∇]	

ATMOSPHERIC TRIP TEST

20ºC ATMOSPHERIC TRIP	TRIP PRESURE	TEMPERATURE	P. CAMP.	MEDIUM VALUES
Trip 1.	17,56 Bar	127,5 ºC	1,05 bar(R)	TRIP PRESSURE = 17,584 Bar
Trip 2.	17,56 Bar	127,5 ºC	↓	VALVE TEMP. = 127,78 ºC
Trip 3.	17,69 Bar	127,7 ºC		AMBIENT PRES. = 1,05 Bar(R)
Trip 4.	17,57 Bar	128,1 ºC		≈ 2 bar (abs)
Trip 5.	17,54 Bar	128,1 ºC		

Realizado RINGO	G.C. RINGO	**ASVAD INTL SL** Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com Insp. Cliente	TÜV SÜD Iberia, S.A.U. Insp. Autorizado

RINGO VALVULAS

TEST CERTIFICATE
AMBIENTAL CALIFICATION
ASVAD VALVE (WO-6056)

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

TEST PROCEDURE
IN8-3-699 Rev. 1

Sheet 2 of 2

DBA ACCIDENT SIMULATION PERIOD

Time T0 (Start): 26/7/18 15:00

Time Td (End): 31/7/18 10:39

TEST	DESIRED VALUE ~~Pd atm + 2,94 bar (±1% PN)~~ 17,58 bar	OBTAINED VALUE	CORRECT? YES/NO	TEMPERATURE
120 ºC & 2,06 Bar TRIP (after 96h)	17.38 bar	17.39 bar	YES	131°C
post DBA TRIP (atmospheric)	16,90 bar	16,90 bar	YES	56,1°C

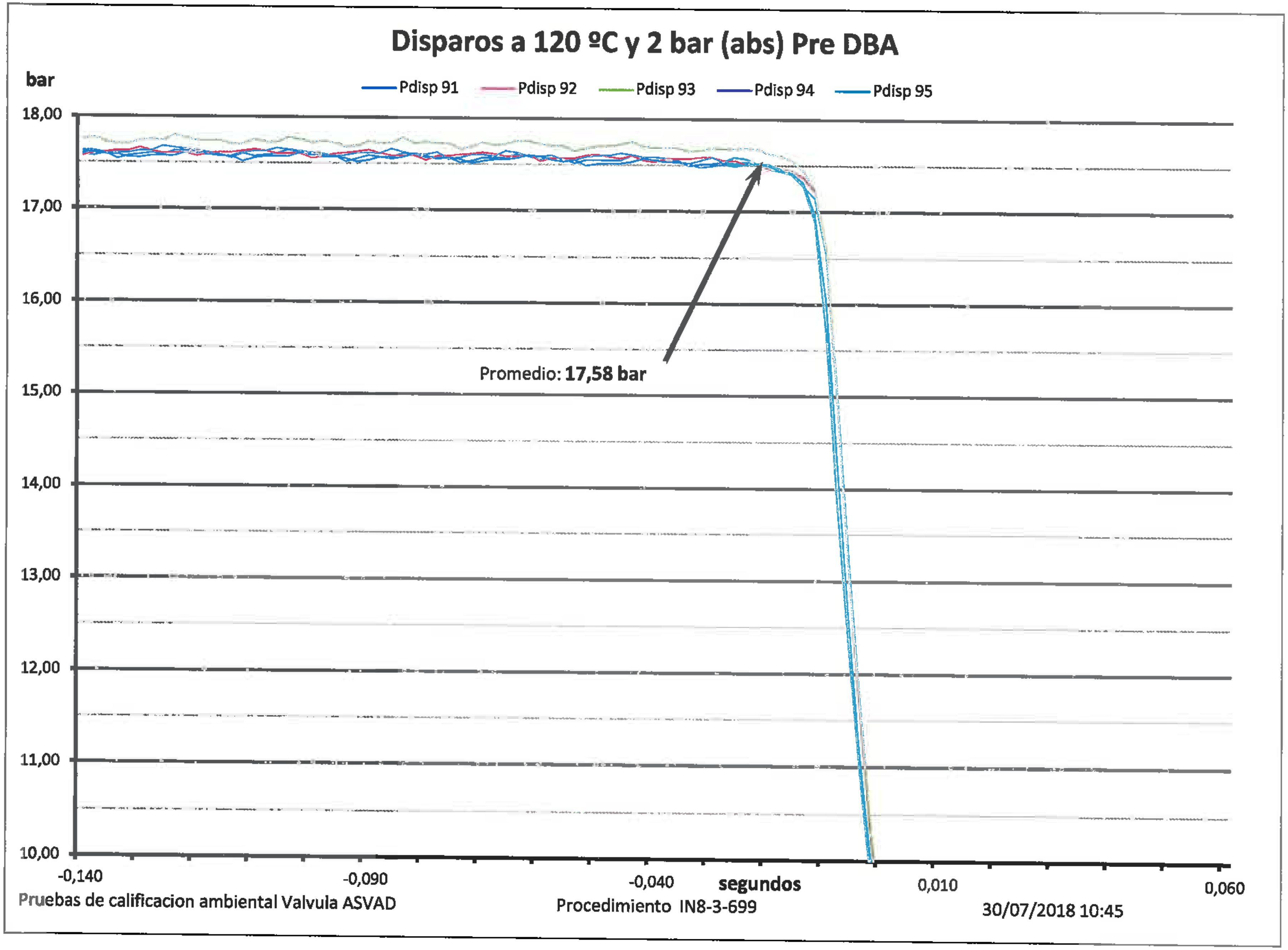
TEST AND MEASUREMENT EQUIPMENT

DESCRIPTION	IDENTIFICATION NUMBER	CALIBRATION DUE DATE	DESCRIPTION	IDENTIFICATION NUMBER	CALIBRATION DUE DATE
REGISTER	Z106310	7/5/19	MANOMETER 0-10 bar	RV-551	JUL-19
PRES. TRANS. 25 bar	2188012	1/2/19	MANOMETER 0-100 bar	RV-518	ABR-19
PRES. TRANS 10 bar	2188015	1/2/19	MANOMETER 0-2 bar abs	2153010	9/5/19
TEMP TRANS 0-200°C	2188013	2/2/19	MANOMETER 0-40 bar	RV-229	DIC-18
CONTROLLER 0-200°C	2186069	2/2/19			

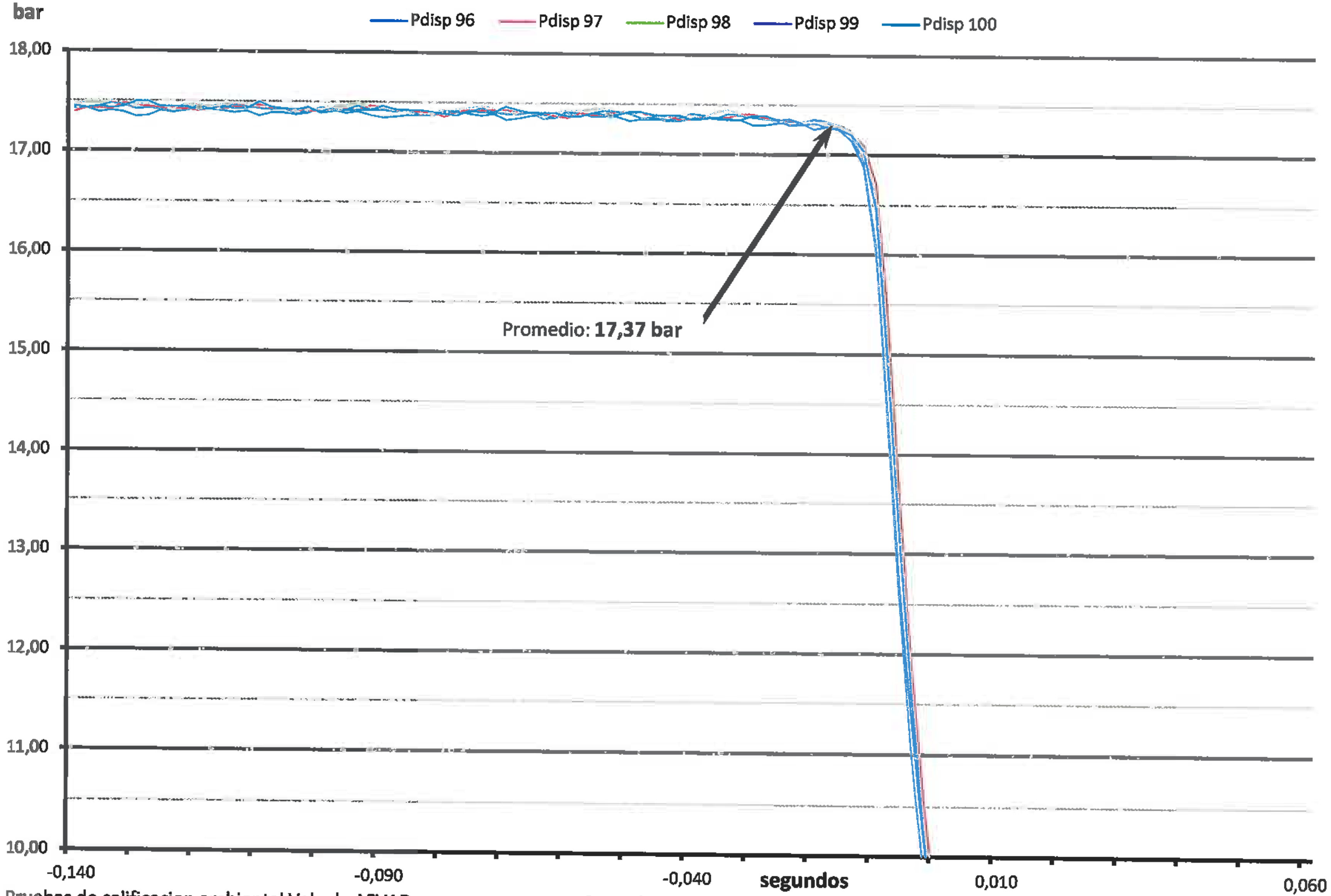
Comments:

- A NEW PERIOD OF HEATING (160°C) IS ADDED AFTER THE 4 DAY TOTAL TIME AT 160°C 13,4 h.
- AFTER THIS TIME. THE VALUE OPENS ONLY 0,2 BAR BELOW THE EXPECTED PRESSURE.

RINGO Executed	RINGO Quality Insp.	ASVAD INTL SL Arnaldo Laborda Rami Gerente / CEO alaborda@asvad-nuclear.com Client Inspector.	A-01670614 Authorized Inspector.


Disparos a 120 ºC y 2 bar (abs) Pre DBA
bar
Pdisp 91
Pdisp 92
Pdisp 93
Pdisp 94
Pdisp 95
18,00
17,00
16,00
15,00
14,00
13,00
12,00
11,00
10,00
Promedio: 17,58 bar
-0,140
-0,090
-0,040
segundos
0,010
0,060
Pruebas de calificacion ambiental Valvula ASVAD
Procedimiento IN8-3-699
30/07/2018 10:45

Disparos a 120 ºC y 2 bar (abs) Post DBA

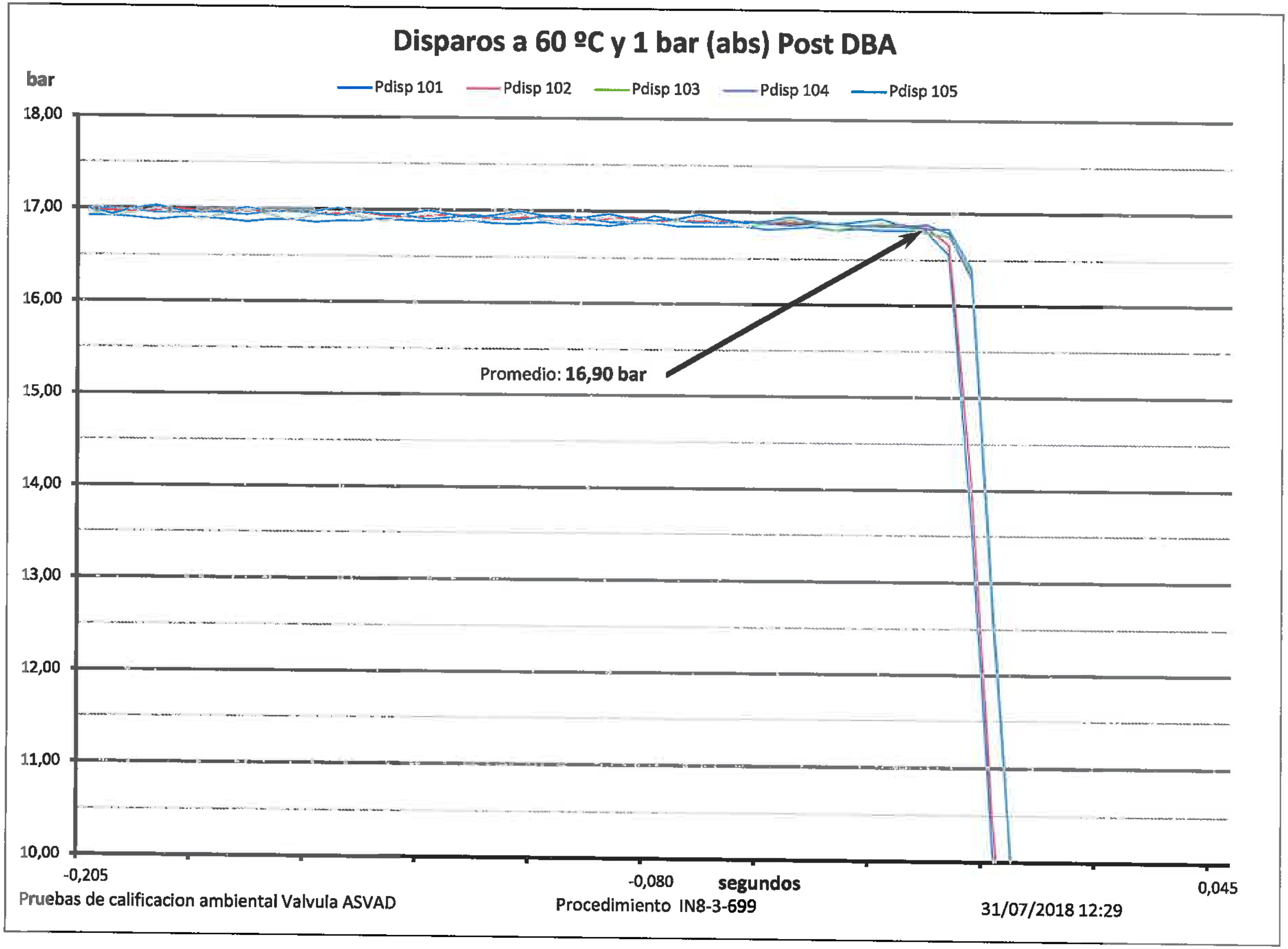


Promedio: **17,37 bar**

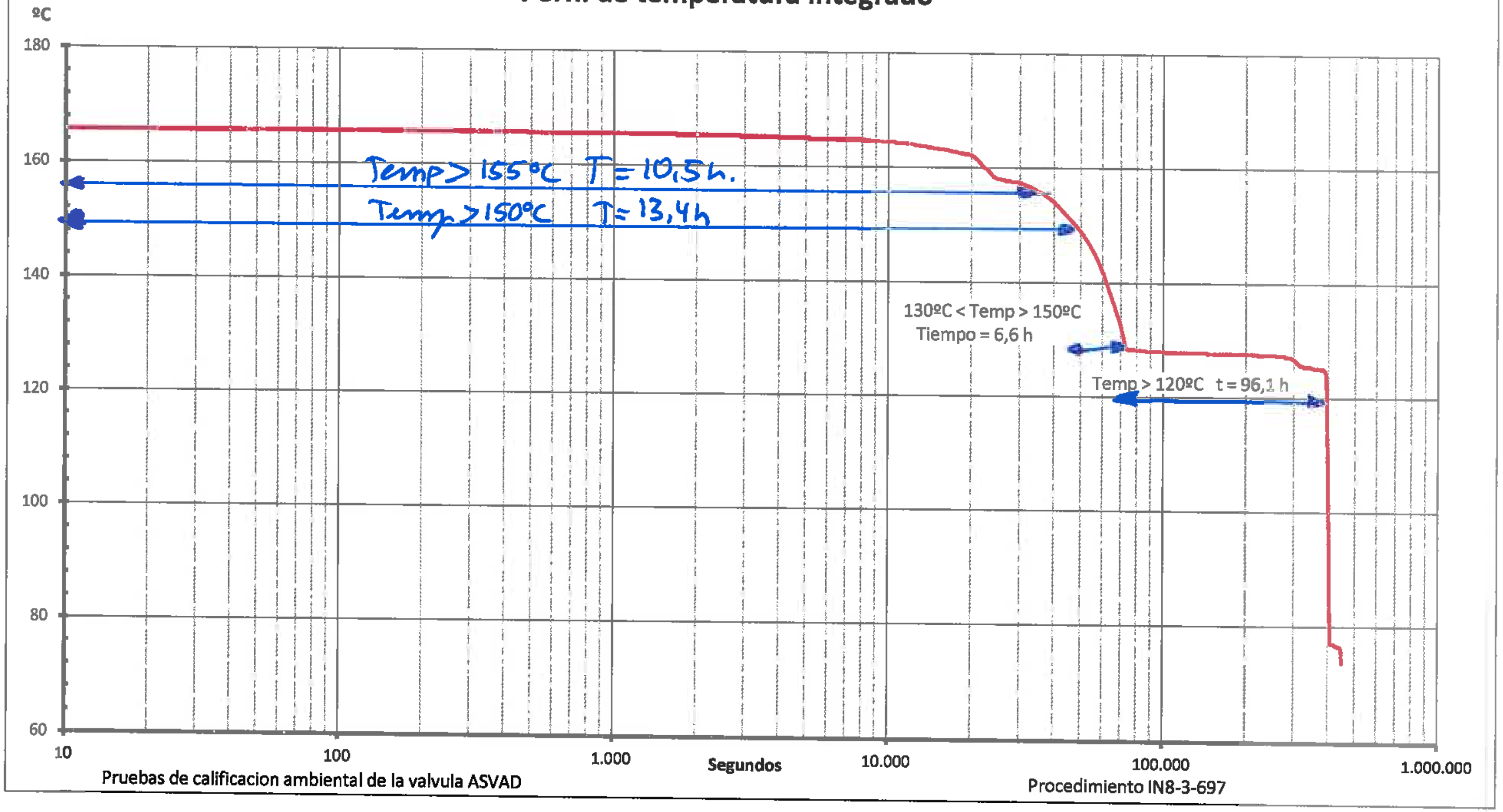
Pruebas de calificacion ambiental Valvula ASVAD

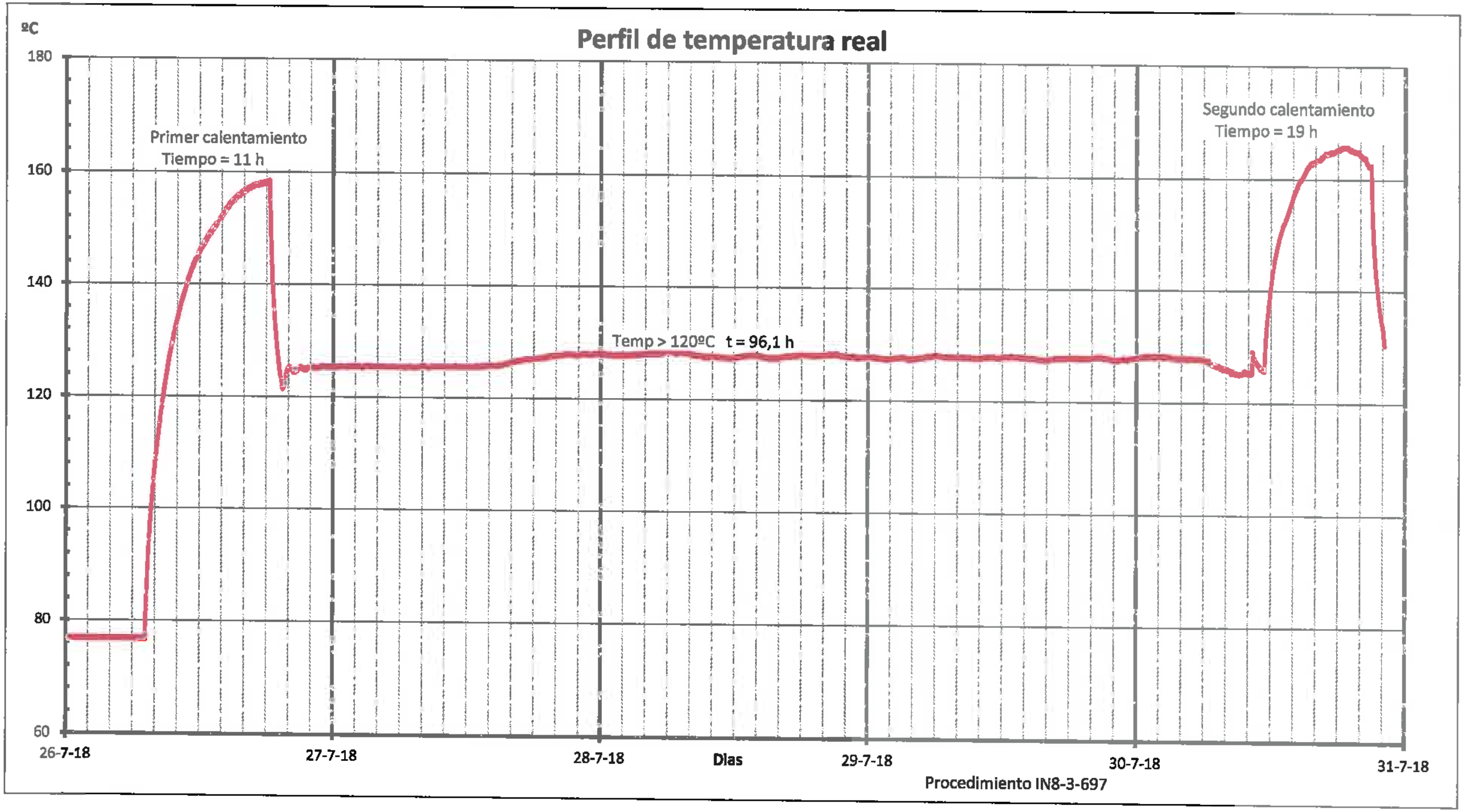
Procedimiento IN8-3-699

31/07/2018 10:43

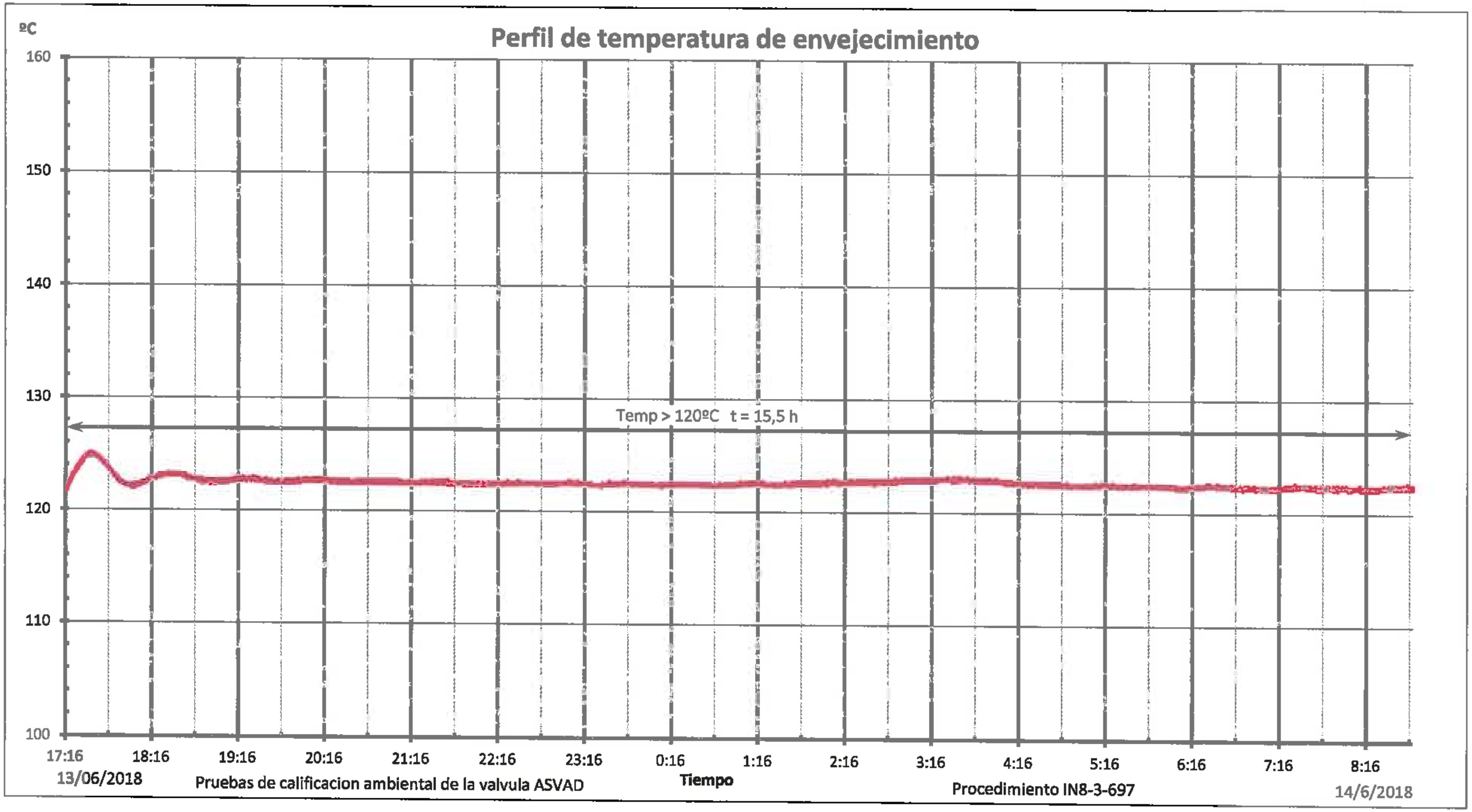

Disparos a 60 ºC y 1 bar (abs) Post DBA
bar
Pdisp 101
Pdisp 102
Pdisp 103
Pdisp 104
Pdisp 105
18,00
17,00
16,00
15,00
14,00
13,00
12,00
11,00
10,00
Promedio: 16,90 bar
-0,205
-0,080
segundos
0,045
Pruebas de calificacion ambiental Valvula ASVAD
Procedimiento IN8-3-699
31/07/2018 12:29

Perfil de temperatura integrado





Perfil de temperatura real


Perfil de temperatura de envejecimiento
ºC
160
150
140
130
120
110
100
Temp > 120ºC t = 15,5 h
17:16
13/06/2018
18:16
19:16
20:16
21:16
22:16
23:16
0:16
1:16
2:16
3:16
4:16
5:16
6:16
7:16
8:16
14/6/2018
Pruebas de calificacion ambiental de la valvula ASVAD
Tiempo
Procedimiento IN8-3-697

ANEXO II **CONFIGURACION DE LAS PRUEBAS**

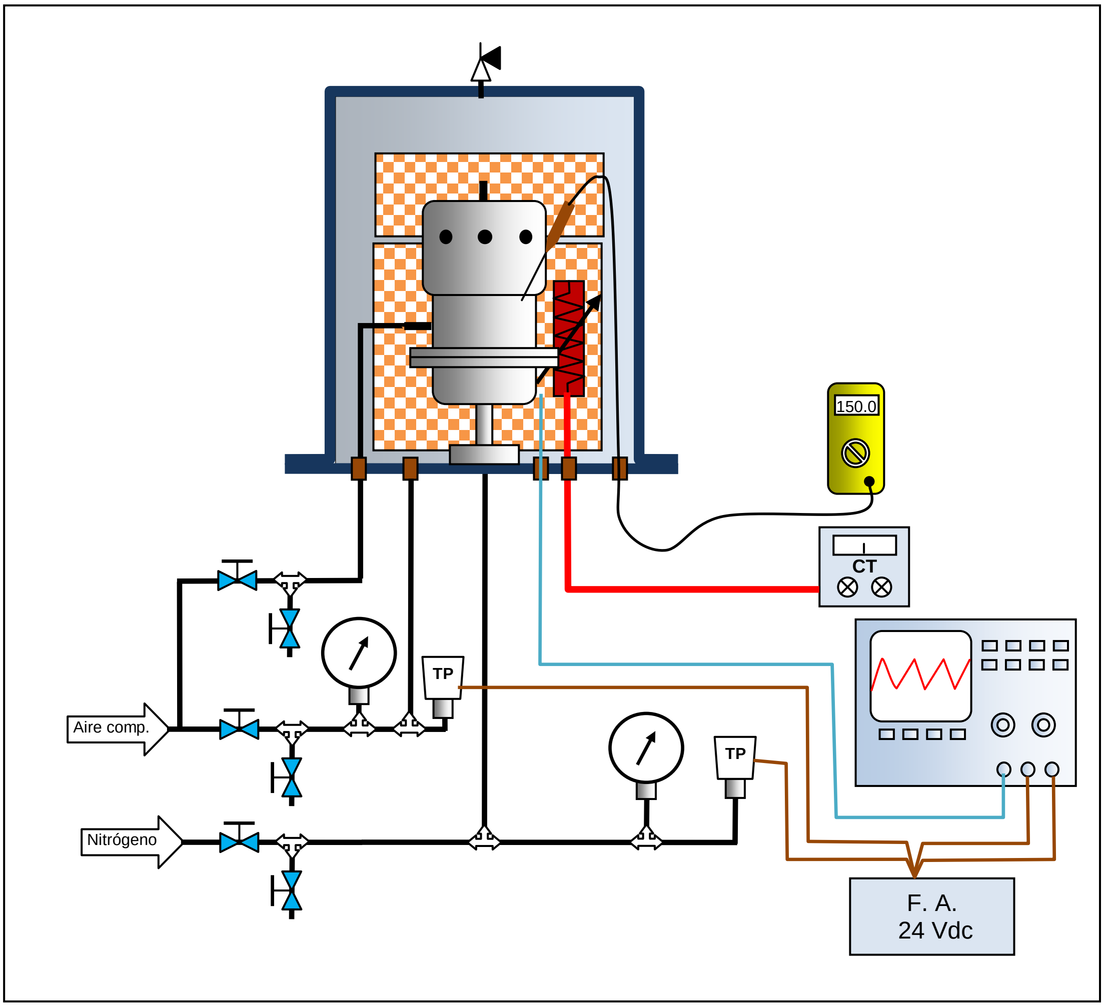


Figura 1. Prueba del aislamiento ambiental.

RINGO VALVULAS	INSTRUCCION	**Nº:** IN8-3-698 **Revisión:** 0 **Fecha:** 04/01/18 **Página:** 1 de 9

Título: Pruebas de Pilotaje de la válvula ASVAD
WO-6056

Revisado:	**Aprobado:**
RESPONSABLE CALIDAD	RESPONSABLE OPERACIONES

0. HISTORIAL DE REVISIONES.

Rev.	**Fecha/*Date***	**Asunto/*Subject***	**Aprobado/*Approved***	**Revisado/*Revised***
0	04/01/2018	Emisión Inicial	JMGM	MO

1. OBJETO.

Este documento tiene por objeto definir las pautas necesarias para llevar a cabo la prueba funcional de pilotaje (apertura y cierre manual) para la válvula ASVAD correspondiente a la WO-6056.

2. CAMPO DE APLICACIÓN.

Esta instrucción aplica a las válvulas fabricadas por Ringo Válvulas S.L. en la obra WO-6056.

3. REFERENCIAS .

Código ASME Sección III, Subsección NB Edición 2015
ISO-5208
ANSI / ASME QME -1- 2012

4. FORMATOS A USAR.

Los formatos del Anexo I se usarán como registro de los resultados de las pruebas. Se rellenaran y firmarán ambos formatos, en español e inglés.

Los datos de prueba requeridos tales como presión, pérdidas, duración de la prueba, etc, serán indicados en la hoja de pruebas antes de realizarse las pruebas. Los resultados reales serán registrados durante la realización de la prueba.

5. PERSONAL.

El personal responsable de la realización de la presente instrucción deberá estar cualificado según IN6-1-4: “Instrucción para la cualificación del personal de inspección, exámenes y pruebas”.

El personal responsable de la realización de la presente instrucción deberá cumplir con las normas de seguridad INMASS-1-7: “Normas de seguridad para prueba de válvulas”.

Precaución: Poner atención en el uso de EPI’s adecuados durante las pruebas.

Las pruebas serán presenciadas y validadas por una persona del Departamento de Garantía de la Calidad de Ringo Válvulas. Así mismo las pruebas pueden ser presenciadas y validadas por un inspector del cliente y/o por un inspector de una agencia autorizada por el cliente.

6. MATERIALES Y EQUIPOS.

6.1. Fluido.

El fluido de pruebas para esta prueba será nitrógeno industrial a temperatura ambiente. También es aceptable su realización con aire comprimido seco o sintético.

Se utilizará líquido buscafugas para la detección de las posibles fugas que pudieran darse.

6.2. Banco de pruebas.

Las pruebas se realizaran con la válvula ASVAD montada en posición vertical en la toma correspondiente del banco de pruebas diseñado especialmente para este fin.

Precaución: la válvula se instalará de forma que en ningún caso la descarga de la misma pueda causar daños tanto a personas como a la instalación.

6.3. Manómetros y transmisores de presión.

Los manómetros de prueba y/o los transmisores de presión estarán calibrados de acuerdo con ASME III, cláusula NB-6400.

Se seleccionarán de tal modo que la presión de prueba esté entre el 10% y el 90% del fondo de escala. La incertidumbre de los manómetros será menor de un 5% del rango.

Se requerirá de los siguientes equipos:
- Manómetro control de PD. Rango aconsejado 20/25 kg/cm2.
- Manómetro presión aire de cierre. Rango aconsejado 16 Bar.

6.4. Termómetro.

Se utilizará un termómetro calibrado con una incertidumbre menor de ± 2ºC y capaz de medir hasta 175ºC.

Prerrequisito: Antes de iniciar las pruebas comprobar que los equipos a utilizar se encuentran en su periodo de validez de calibración. Anotar su identificación en la hoja de registro.

7. PRUEBAS DE CIERRE Y APERTURA MANUAL.

Prerrequisito: Antes de iniciar las pruebas comprobar la integridad de la válvula, la ausencia de marcas o golpes, así como de cualquier otro daño que pueda afectar al funcionamiento de la misma. Se recomienda que la rosca interna del obturador se haya lubricado adecuadamente antes del inicio de la prueba.

Precaución: No manipular los elementos de la válvula o del sistema de prueba bajo presión. Si es necesario realizar algún reapriete, o reajuste de conexiones despresurizar completamente el sistema antes de proceder a ello.

Precaución: Una vez armada, la despresurización de la válvula por debajo de su punto de disparo, provoca el disparo de la válvula. Riesgo de proyecciones.

Precaución: Dado que la prueba se realiza con gas, proteger el entorno de la válvula mediante barreras físicas que eviten los riesgos de proyección de misiles que puedan derivarse de un fallo estructural en la misma o en el sistema de prueba. Minimizar la parte de la instalación sometida a presión.

La Presión Mínima para el Cierre (PMC) y la Presión Mínima para la Apertura (PMA) para todas las válvulas sujetas a esta instrucción son dependientes de las características del muelle instalado. Ir anotando en el formato los sucesivos valores obtenidos durante la ejecución de las pruebas.

7.1. Montar el sistema de pruebas según se indica en la figura 1 del anexo II.

7.2. Desmontar la tapa superior para poder tener acceso a la salida superior del obturador.

7.3. Con la herramienta de ajuste de presión, tensar completamente el muelle girando en sentido antihorario el obturador hasta su tope. Esta posición se alcanza cuando los testigos antigiro <u>están a ras del almenado del obturador</u> y coincide con el punto superior de disparo de la válvula.

7.4. Asegurarse de que no hay presión en la cámara inferior de la válvula.

7.5. Incrementar lentamente la presión en la entrada de armado hasta conseguir cerrar el obturador. Anotar esta presión (PMC) y la temperatura en el casillero correspondiente del formato.

7.6. Incrementar dicha presión hasta 15 bares y cerrar la válvula de entrada.

Mantener al menos 10 minutos. Comprobar que la presión en la cámara no disminuye. Apuntar la presión y la temperatura en el casillero correspondiente del formato.

7.7. Despresurizar completamente la entrada de armado. Comprobar que el obturador queda abierto.

7.8. Con la herramienta de ajuste de presión, destensar completamente el muelle girando en sentido horario el obturador hasta su tope. Esta posición se alcanza cuando los testigos antigiro <u>están a ras de la superficie superior</u> y coincide con el punto inferior de disparo de la válvula.

7.9. Montar la tapa superior, teniendo cuidado de **retirar** todos los tapones de cierre.

7.10. Montar el sistema de pruebas según se indica en la figura 2 del anexo II.

7.11. Cerrar el obturador de la válvula aplicando aire comprimido en la entrada de armado. Mantener dicha presión mientras la presión en la cámara inferior de la válvula sea inferior al 130% de la presión de disparo.

7.12. Presurizar la cámara inferior de la válvula con una presión inicial de al menos el 110% de su PN. Una vez a esta presión, despresurizar completamente la entrada de armado.

7.13. **Precaución: Riesgo de proyecciones al disparar la válvula.** En estas condiciones, incrementar lentamente la presión en la entrada de apertura (entrada superior) hasta conseguir disparar la válvula. Anotar esta presión (PMA) y la temperatura en el casillero correspondiente del formato.

7.14. Incrementar dicha presión hasta 15 bares y cerrar la válvula de entrada. Mantener al menos 10 minutos. Comprobar que la presión en la cámara superior no disminuye. Apuntar la presión y la temperatura en el casillero correspondiente del formato.

7.15. Despresurizar definitivamente la entrada de apertura. Fin de la prueba.

8. NORMALIZACION.

Si no se van a realizar más pruebas, retirar las conexiones de presión y desmontar la válvula del banco.

9. CRITERIOS DE ACEPTACION.

Los Criterios de aceptación para esta prueba son los siguientes:

Para el sistema de cierre:
- Con el muelle ajustado a su máxima tensión, la válvula en posición abierta (disparo), y su cámara inferior comunicada con la atmosfera, la presión mínima necesaria para el cierre (PMC) obtenida es menor o igual que la mínima indicada en las especificaciones (4 Bar).
- La cámara del pistón de cierre es capaz de soportar y mantener la estanqueidad a la presión máxima de pilotaje (15 Bar) durante 10 minutos.

Para el sistema de apertura:
- Con el muelle ajustado a su mínima tensión, la válvula en posición cerrada y su cámara inferior a una presión del 110% de la PN, la presión mínima necesaria para la apertura (PMA) obtenida es menor o igual que la mínima indicada en las especificaciones (4 Bar).
- La cámara del pistón de apertura es capaz de soportar y mantener la estanqueidad a la presión máxima de pilotaje (15 Bar) durante 10 minutos.

10. ANEXOS

I. Hoja de datos FORMATO F8-3-698.
II. Configuración de las pruebas.

RINGO VALVULAS

TEST CERTIFICATE OF MANUAL OPENING AND CLOSURE ASVAD VALVE (WO-6056)

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

TEST PROCEDURE

IN8-3-698 Rev. 0

Sheet 1 of 1

CLIENT ASVAD INTL SL

Ref. CLIENT

SITE WO-6056

ITEM ASVAD -1

DATA 22/2/18

VALVE IDENTIFICATION	SERIAL		NOMINAL PRESSURE PN	50 bar
	MODEL		TRIP PRESSURE PD	12,81 bar
VISUAL INSPECTION		VALVE INTEGRITY OK? [✓ YES ∆] NO ∇		OBSERVED DAMAGES? YES ∆ [✓ NO ∇]

MANUAL CLOSURE TEST

	DESIRED VALUE	OBTAINED VALUE	CORRECT? YES/NO	TEMPERATURE
MINIMUM CLOSURE PRESSURE (PMC)	≤ 4 Bar	2,9 bar	Y	16,1 °C
MAXIMUM CLOSURE PRESSURE	≥ 15 Bar	15 bar	Y	17,6 °C

MANUAL OPENING TEST

	DESIRED VALUE	OBTAINED VALUE	CORRECT? YES/NO	TEMPERATURE
MINIMUM OPENING PRESSURE (PMA)	≤ 4 Bar	3,54 bar	Y	17,6°C
MAXIMUM OPENING PRESSURE	≥ 15 Bar	15 bar	Y	17,6°C

MEASUREMENT AND TEST EQUIPMENT

DESCRIPTION	IDENTIFICATION NUMBER	CALIBRATION DUE DATE
MANOMETER 0-25 bar / MANOMETER 0-60 bar	RV 323 / RV-434	MAR-18 / SEPT-18
REGISTER / PRESS TRANS. 25 bar	2106310 /2188012	10/5/18 / 1/2/19
TERMOMETER / TEMP. TRANS. 0 · 200°C	2186010 /2188013	3/5/18 / 2/2/19

Comments:

ASVAD INTL SL
Arnaldo Laborda Rami
Gerente / CEO
alaborda@[illegible]

TÜV SÜD Iberia, S.A.U.

RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.

ANEXO II CONFIGURACION DE LAS PRUEBAS

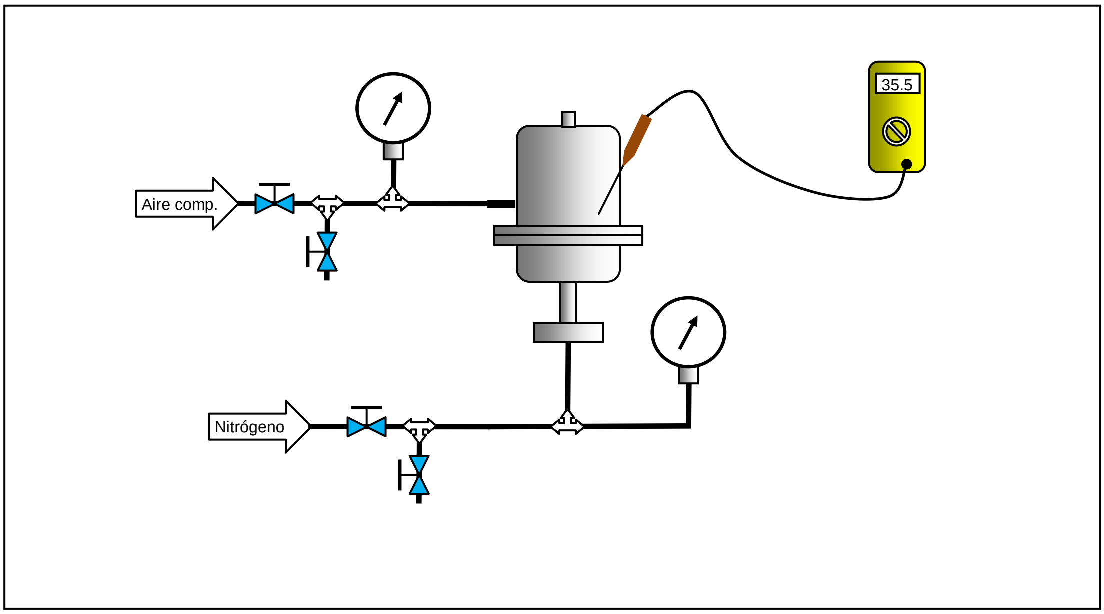


Figura 1. Prueba del cierre manual

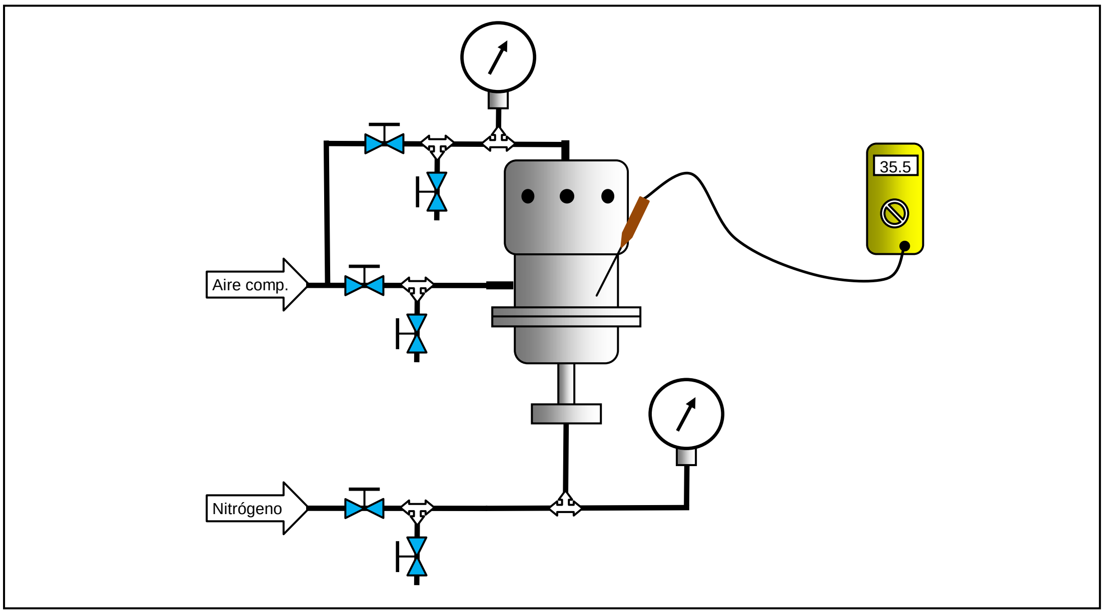


Figura 2. Prueba de Apertura manual.

RINGO VALVULAS	# INSTRUCCION	**Nº:** IN8-3-700 **Revisión:** 0 **Fecha:** 04/01/18 **Página:** 1 de 6

Título: Inspección visual de la válvula ASVAD
WO-6056

Revisado:	**Aprobado:**
RESPONSABLE CALIDAD	RESPONSABLE OPERACIONES

1. HISTORIAL DE REVISIONES.

Rev.	Fecha/*Date*	Asunto/*Subject*	Aprobado/*Approved*	Revisado/*Revised*
0	04/01/2018	Emisión Inicial	JMGM	MO

2. OBJETO.

Este documento tiene por objeto definir las pautas necesarias para llevar a cabo la inspección visual de la válvula ASVAD (WO-6056).

3. CAMPO DE APLICACIÓN.

Esta instrucción aplica a las válvulas fabricadas por Ringo Válvulas S.L. en la obra WO-6056.

4. REFERENCIAS.

ISO-5208
ANSI / ASME QME -1- 2012
Plano RV-E1306-3

5. FORMATOS A SER USADOS.

El formato del Anexo I se usará como registro de la realización de las pruebas. Este registro incluirá la aceptación de Ringo Válvulas S.L., del inspector autorizado o tercera parte y del Inspector del cliente.

6. PERSONAL.

El personal responsable de la realización de la presente instrucción deberá estar cualificado según IN6-1-4: “Instrucción para la cualificación del personal de inspección, exámenes y pruebas”.

Precaución: Poner atención en el uso de EPI's adecuados durante las pruebas.

Las pruebas serán presenciadas y validadas por una persona del Departamento de Garantía de la Calidad de Ringo Válvulas. Así mismo las pruebas pueden ser presenciadas y validadas por un inspector del cliente y/o por un inspector de una agencia autorizada por el cliente.

7. MATERIALES Y EQUIPOS.

No aplican.

8. INSPECCION VISUAL.

Durante todo el proceso de inspección se tendrá a disposición el plano RV-E1306-3 con la disposición de elementos internos de la válvula.

Realizar una Inspección visual del exterior de la válvula, prestando especial atención en los siguientes aspectos:

8.1. Brida inferior.

Comprobar que la superficie de contacto de la brida inferior, presenta una superficie plana y libre de desperfectos o rayaduras.

8.2. Cuerpo inferior.

Comprobar que el aspecto de la superficie exterior, presenta una superficie lisa y libre de desperfectos o rayaduras.

Comprobar que los espárragos de unión están perfectamente alineados y apretados, y que el cuerpo inferior hace perfecto contacto con el cuerpo intermedio.

8.3. Cuerpo medio.

Comprobar que el aspecto de la superficie exterior, presenta una superficie lisa y libre de desperfectos o rayaduras.

Comprobar que la toma de aire de cerrar no se encuentra doblada o chafada. Si está visible, comprobar que su rosca está en buen estado.

Comprobar que el cuerpo medio hace perfecto contacto con la tapa superior y que esta se encuentra completamente roscada al mismo.

8.4. Tapa superior.

Comprobar que el aspecto de la superficie exterior, presenta una superficie lisa y libre de desperfectos o rayaduras.
Comprobar que dispone de todos los tapones y que estos se encuentran perfectamente insertados en sus respectivos agujeros.

Comprobar que los tapones se encuentran unidos entre sí mediante un cable flexible. Comprobar que este cable no presenta deterioros y permite el suficiente juego como para que los tapones puedan ser separados de la válvula.

Si esta visible, comprobar la entrada de aire de apertura. Verificar que no presenta obstrucciones o suciedad y que su rosca se encuentra en buenas condiciones.

La inspección externa finaliza aquí. Si es posible y conveniente el desmontaje de la válvula, se puede continuar la inspección de las siguientes partes internas:

Tras desmontar el cuerpo inferior, comprobar lo siguiente:

- El cuerpo inferior dispone del deflector interno y este esta adecuadamente atornillado.
- La zona interior de la cámara de presión, presenta una superficie lisa y libre de desperfectos o rayaduras, en especial la zona de la junta.
- La junta de cierre de la cámara de presión está correctamente colocada y se adapta bien en su ranura.
- La junta principal de cierre está perfectamente sujeta por el aro de metal y sus tornillos están apretados.
- La junta principal de cierre presenta un buen aspecto y no se observan desperfectos, mordidas o rajaduras.
- La superficie de contacto del obturador principal presenta una superficie lisa y libre de desperfectos o rayaduras, en especial la zona de la junta.

Tras desmontar la tapa superior, comprobar lo siguiente:

- El cilindro equilibrador está completamente roscado al cuerpo intermedio.
- El contenedor del muelle queda a ras del cilindro equilibrador.
- la superficie interna de la tapa superior presenta una superficie lisa y libre de desperfectos o rayaduras, en especial la zona de la junta.
- Los agujeros del pistón de apertura no están obstruidos.
- La junta entre el cuerpo medio y la tapa superior presión está correctamente colocada y se adapta bien en su ranura.
- La salida del obturador principal no está obstruida.

Tras desmontar el cilindro equilibrador, comprobar lo siguiente:

- El contenedor del muelle puede desplazarse longitudinalmente por el interior del cilindro equilibrador.
- Tras retirar el muelle principal, las dos guías antigiro permiten el desplazamiento guiado del contenedor del muelle

Tras desmontar el contenedor del muelle, comprobar lo siguiente:

- las dos guías antigiro están completamente atornilladas en los orificios del disco de ajuste y quedan paralelas al obturador principal.

Tras desmontar el disco de ajuste, comprobar lo siguiente:

- La rosca del obturador principal se encuentra en buen estado.
- La superficie externa del obturador principal presenta una superficie lisa y libre de desperfectos o rayaduras.

Tras desmontar el pistón de cierre, comprobar lo siguiente:

- La superficie interna de contacto del obturador principal presenta una superficie lisa y libre de desperfectos o rayaduras, en especial la zona de la junta.
- La superficie externa del cilindro de cierre presenta una superficie lisa y libre de desperfectos o rayaduras, en especial la zona de la junta.
- El cilindro de cierre está correctamente atornillado al cuerpo medio.
- Las juntas del pistón de cierre están correctamente colocadas y se adaptan bien en su ranura.

Tras desmontar el cilindro de cierre, comprobar lo siguiente:

- La junta inferior del cilindro de cierre está correctamente colocada y se adapta bien en su ranura.

9. CRITERIOS DE ACEPTACION.

No hay criterios específicos de aceptación. Quedan a juicio del inspector.

10. ANEXO I

VER FORMATO F8-3-700

RINGO VALVULAS

ASVAD VALVE (WO-6056)

VISUAL INSPECCTION

RINGO VÁLVULAS, S.L.
Polígono Empresarium
Calle Romero nº 6
50720 Zaragoza (España)

PROCEDURE

IN8-3-700 Rev. 0

Sheet 1 from 1

DATE 21/ 2/ 18 HOUR 13: 20 ACTIVITY: INITIAL INSPECTION

NOTES: INITIAL INSPECTION RESULTS:

- FLANGE → OK
- LOWER BODY → OK
- MEDIUM BODY → OK
- UPPER BODY → OK
- TAPS → OK

THE VALVE IS DISASEMBLED TO PERFORM LUBRICATION. INNER COMPONENTS ARE INSPECTED.

- MAIN OBTURATOR → OK
- EQUILIBRIUM CYLINDER → OK
- CLOSING PISTON → OK
- OPENING PISTON → OK
- SPRINGS → OK
- ADJUSTING DISK → OK.

DATE 20/ 8/ 12 HOUR 12: 00 ACTIVITY: FINAL INSPECTION

NOTES: THE VALVE IS DISSASSEMBLED

- OBTURATOR → OK
- LOCKING CILINDER → OK
- OPENING PISTON → OK
- CLOSING " → OK.
- SPRINGS → OK . SHOWS SOME OXIDATION
- ADJUSTMENT DISK → OK

ASVAD INTL SL
Arnaldo Laborda Rami
Gerente / CEO
alaborda@asvad-nuclear.com

TÜV SÜD Iberia S.A.U.

RINGO Executed	RINGO Quality Insp.	Client Inspector.	Authorized Inspector.

ANNEX IV

ASVAD VALVE
SEISMIC CALCULATIONS

DC-6056-1 r0

DESIGN CALCULATION

DESIGN CALCULATION No.:	DC-6056-1
REVISION:	0
ASSEMBLY DRAWING:	RV-E1306
DESIGN PRESSURE:	19 bar(g)
DESIGN TEMPERATURE:	130°C
VALVE TYPE:	SAFETY GLOBE VALVE
VALVE SIZE:	1"
VALVE RATING CLASS:	300#
DESIGN STANDARD:	ASME III Div.1 Subsection NC (Ed. 2007 addenda 2008)
NUCLEAR CLASS:	CN2
SEISMIC CLASS:	I

	DATE	NAME
PERFORMED BY:	22/01/2018	***A. Aguilar***
REVIEWED BY:	22/01/2018	***J.M. Obón***
APPROVED BY:	22/01/2018	***J.M. García***

SAMSON RINGO
ENGINEERING AND R+D+I DEPARTMENT

REVISION HISTORY RECORD

REVISION	DATE	PREPARED BY	REVIEWED BY	APPROVED BY	DESCRIPTION
0	*22/01/2018*	*A.Aguilar*	*J.M.Obón*	*J.M.García*	*Initial issue*

0. Index

I. Introduction

This document presents the evaluation and analysis of the valve described on the cover sheet as SAFETY GLOBE VALVE 1" 300# and represented on assembly drawing number RV-E1306.

The purpose of this report is to show that valve design is in compliance with the requirements of the following codes and editions:

- *ASME III Div.1 Subsection NC (Ed. 2007 addenda 2008)*

II. Material properties chart

Material properties for main parts from ASME II, Part D, Subpart 1 Tables 1A, Y-1 and subpart 2 Table TM-1

POSITION	MATERIAL	YIELD STRENGTH ROOM TEMP.	YIELD STRENGTH DESIGN TEMP.	ALLOWABLE STRESS ROOM TEMP.	ALLOWABLE STRESS DESIGN TEMP.	ELASTICITY MODULUS ROOM TEMP.	ELASTICITY MODULUS DESIGN TEMP.	TENSILE STRENGTH
BODY Austenitic Forged	SA182 F316L	207	166	138	138	195000	187200	515
OBTURATOR	A564 Gr.630 H1075	862	774	285	285	196000	189200	1000
LOWER BONNET	SA182 F316L	207	166	138	138	195000	187200	515
BODY/BONNET BOLTING	SA453 Gr660B	586	658	147	147	201000	193600	895

NOTE:

- All values are in MPa
- Mechanical properties for SA182 F316L are the same as SA182 F316

III. Calculation summary

The calculation results for the analyzed components are summarized in this paragraph.

Calculation method, load combination and acceptance criteria for the analysis of each component has been referenced on applicable calculation chapter.

COMPONENT	CALCULATED	ALLOWABLE / REQUIRED	RATIO	CHAPTER
CHAPTER 1. MINIMUM WALL THICKNESS				
Minimum required wall thickness		Required		
Minimum entrance flange wall thickness (mm)	5,50	5,30	0,96	1.1.
Minimum lower bonnet wall thickness (mm)	12,40	10,40	0,84	1.2.
CHAPTER 2. NATURAL FREQUENCY ANALYSIS				
Natural frequency of extended structure		Required		
Natural frequency (Hz)	52,07	50,00	0,96	2.4.
CHAPTER 3. ENTRANCE FLANGE NECK STRESSES				
Body neck stresses		Allowable		
Maximum membrane stress (MPa)	47,61	151,80	0,31	3.6.
Maximum membrane plus bending stress (MPa)	220,66	227,70	0,97	3.9.
CHAPTER 4. BODY/BONNET FLANGE ANALYSIS				
Body/Bonnet bolting		Required		
Bolting required area (mm^2)	732,40	276,69	0,38	4.2.1.(C)
Bonnet flange		Allowable		
- Design conditions				
Longitudinal hub stress (MPa)	59,38	207,00	0,29	4.2.4.(A)
Radial stresses on flange (MPa)	58,04	138,00	0,42	4.2.4.(A)
Tangential stresses on flange (MPa)	35,31	138,00	0,26	4.2.4.(A)
Maximum of medium stresses (MPa)	58,71	138,00	0,43	4.2.4.(A)
- Seat conditions				
Longitudinal hub stress (MPa)	107,67	207,00	0,52	4.2.4.(B)
Radial stresses on flange (MPa)	105,25	138,00	0,76	4.2.4.(B)
Tangential stresses on flange (MPa)	64,03	138,00	0,46	4.2.4.(B)
Maximum of medium stresses (MPa)	106,46	138,00	0,77	4.2.4.(B)
CHAPTER 5. DISC CALCULATION				
Disc stresses		Allowable		
Maximum disc bending stress (MPa)	49,75	427,50	0,12	5.1.

IV. Conclusion

The results obtained in the different chapters of section V.Calculations show that the valve design meets the requirements indicated by the applicable standards and customer specifications.

Additionally, it is also concluded the following facts:

- Pressure retaining parts have been assessed: Minimum required wall thickness is verified according to ASME B16.34. Body to lower bonnet flanged connection has been calculated according to ASME III, App XI, getting that bonnet flange thickness meets the required thickness.

- An analysis of the natural frequency of the extended structure over the pipe run is done to prevent possible resonance effects. With this calculation it is concluded that the behavior of the analyzed structure is correct against seismic loads.

- For obturator, the maximum bending stress is calculated getting that the resulting stress is correct against stress limits.

V. Calculations

Chapter 1

Minimum wall thickness

1. MINIMUM WALL THICKNESS

Minimum required wall thickness is verified according to NC-3512. The design of the valve shall conform to the applicable requirements of ASME B16.34. Shall be anticipated a corrosion thickness of 1 mm for stainless steel.

1.1. Minimum entrance flange wall thickness (Pos. 173)

General data

d_m	*Entrance flange inner diameter*	*25,40 mm*
t_m	*Minimum wall thickness required by B16.34 chart 3*	*4,3 mm*
t_c	*Corrosion required increased thickness*	*1,00 mm*
t	*Actual thickness*	*5,50 mm*

$t_{req} = t_m + t_c =$ **5,30 mm**

$t > t_{req}$ **5,5 mm > 5,3 mm** **OK**

1.2. Minimum lower bonnet wall thickness (Pos. 25)

General data

d_m	*Bonnet inner diameter*	*150,00 mm*
t_m	*Minimum wall thickness required by B16.34 chart 3*	*9,4 mm*
t_c	*Corrosion required increased thickness*	*1,00 mm*
t	*Actual thickness*	*12,40 mm*

$t_{req} = t_m + t_c =$ **10,40 mm**

$t > t_{req}$ **12,4 mm > 10,4 mm** **OK**

Chapter 2

Natural frequency analysis

2. NATURAL FREQUENCY

Natural frequency is calculated as a cantilevered beam embedded. The method used to calculate the first mode of vibration is Rayleigh's method with 1 degree of freedom and shall be greater than 50 Hz:

$$f_n = \frac{1}{2\pi}\sqrt{\frac{G}{y}} \geq 50Hz$$

General data

E	*Elasticity modulus at design temperature*	*187200,00 MPa*
G	*Gravity acceleration*	*9800,00 mm/s²*
W_A	*Weight above section A-A*	*520,00 N*
D_A	*Outer diameter of body neck*	*41,00 mm*
d_A	*Inner diameter of body neck*	*25,40 mm*
Y_A	*Combined center of gravity*	*227,00 mm*

2.1. MOMENT OF INERTIA I_A

Moment of inertia for circular section of body neck as follows:

$$I_A = \frac{\pi(D_A^4 - d_A^4)}{64} = \quad \mathbf{118277{,}51\ mm^4}$$

2.2. DISPLACEMENTS

Here, the displacement required to calculate the natural frequency is calculated.

$$y = W_A \cdot Y_1 = \quad \mathbf{9{,}16E\text{-}02\ mm}$$

where Y_{11} *is the stiffness coefficient:*

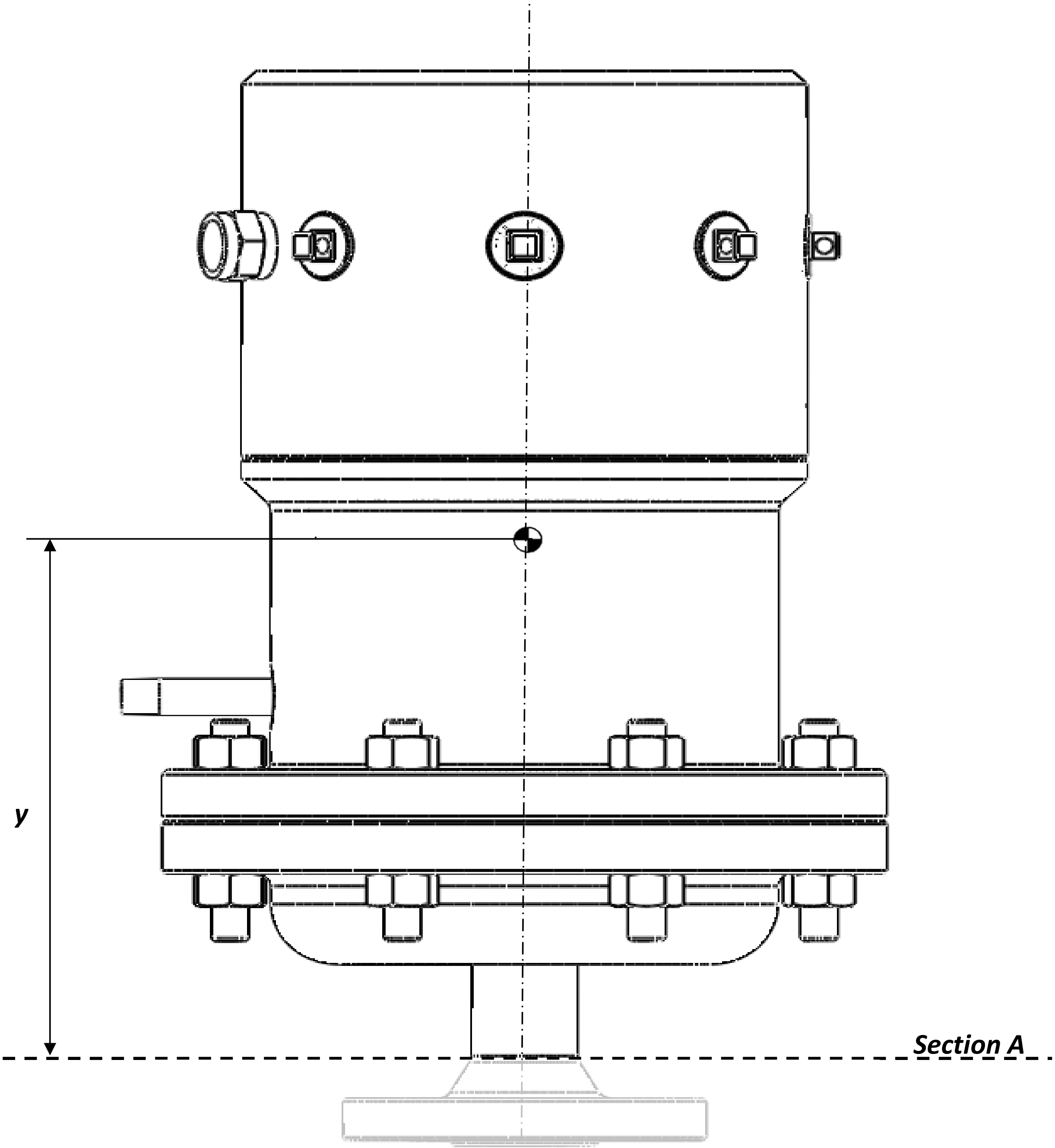
$$Y_1 = \frac{Y_A^3}{3EI_A} = \quad \mathbf{1{,}76E\text{-}04\ mm/N}$$

2.3. NATURAL FREQUENCY

Therefore, the first mode of vibration is:

$$f_n = \frac{1}{2\pi}\sqrt{\frac{G}{y}} \geq 50Hz$$

52,07 Hz > 50 Hz ***OK***


y
Section A

Chapter 3

Entrance flange neck stresses

3. ENTRANCE FLANGE NECK STRESSES

Entrance flange neck stresses are calculated applying equations of general theory of mechanics according to 'Shigley's Mechanical Engineering' 8th Edition.

It is considered a service level B for the following load combination:
Design pressure + Weight + Dynamic loads + Activation forces

Stress verification according to NC-3522.

General data

W_A	*Weight of extended mass above section A-A*	*520,00 N*
X_A	*Combined center of gravity*	*0,00 mm*
Y_A	*Combined center of gravity*	*227,00 mm*
G	*Medium diameter of gasket*	*150,00 mm*
P	*Design pressure*	*1,90 MPa*
E_a	*Maximum actuator thrust*	*0,00 N*
M_a	*Maximum Actuator torque*	*0,00 Nmm*
A_{cv}	*Vertical acceleration*	*6,00 g*
A_{ch}	*Horizontal acceleration* $A_{CH} = A_{CV} \times \sqrt{2}$	*8,49 g*
D_A	*Outer diameter of section A-A*	*41,00 mm*
d_A	*Inner diameter of section A-A*	*25,40 mm*
S_A	*Allowable entrance flange stress at design temperature*	*138,00 MPa*

3.1. SECTION MODULUS AND AREA IN SECTION A-A

Section modulus for circular section

$$J_A = \frac{\pi(D_A^4 - d_A^4)}{32D_A} = \qquad \mathbf{5769{,}63\ mm^3}$$

Polar section modulus for circular section in torsion

$$J_{O|A} = \frac{\pi(D_A^4 - d_A^4)}{16D_A} = \qquad \mathbf{11539{,}27\ mm^3}$$

Area for circular section

$$A_A = \frac{\pi(D_A^2 - d_A^2)}{4} = \qquad \mathbf{813{,}55\ mm^2}$$

3.2. TANGENTIAL STRESS

3.2.1. Tangential stress due to the internal pressure

$$S_T = \frac{P\left({}^{d_A}/_{2}\right)^2}{\left({}^{D_A}/_{2}\right)^2 - \left({}^{d_A}/_{2}\right)^2} \cdot \left(1 + \frac{\left({}^{D_A}/_{2}\right)^2}{\left({}^{d_A}/_{2}\right)^2}\right) =$$

4,27 MPa

3.3. LONGITUDINAL STRESS

3.3.1. Longitudinal stress for a cylindrical shell due to the internal pressure

$$S_{L1} = \frac{P\left({}^{d_A}/_{2}\right)^2}{\left({}^{D_A}/_{2}\right)^2 - \left({}^{d_A}/_{2}\right)^2} =$$

1,18 MPa

3.3.2. Longitudinal stress due to the internal pressure

$$S_{L2} = \frac{\pi \cdot G^2 \cdot P}{4A_A} =$$

41,27 MPa

3.3.3. Longitudinal stress due to weight and dynamic loads

$$S_{L3} = \frac{(A_{CV} + 1)W_A}{A_A} =$$

4,47 MPa

3.3.4. Longitudinal stress due to the stem thrust

$$S_{L4} = \frac{E_a}{A_A} =$$

0,00 MPa

3.3.5. Total longitudinal stress

$$S_L = S_{L1} + S_{L2} + S_{L3} + S_{L4} =$$

46,93 MPa

3.4. SHEAR STRESS

3.4.1. Shear stress due to the actuator torque

$$t_{t1} = \frac{M_a}{J_{o|A}} =$$

0,00 MPa

3.4.2. Shear stress due to horizontal acceleration

$$t_{t2} = \frac{A_{CH} \cdot W_a}{A_A} =$$

5,42 MPa

3.4.3. Total shear stress

$$t_t = t_{t1} + t_{t2} =$$

5,42 MPa

3.5. MAXIMUM PRIMARY MEMBRANE STRESS

Principal stresses according to Mohr's circle.

$$P_{m1} = \frac{S_T + S_L}{2} + \sqrt{\left(\frac{S_T - S_L}{2}\right)^2 + t_t^2} = \qquad \textbf{47,61 MPa}$$

$$P_{m2} = \frac{S_T + S_L}{2} - \sqrt{\left(\frac{S_T - S_L}{2}\right)^2 + t_t^2} = \qquad \textbf{3,59 MPa}$$

3.6. MAXIMUM MEMBRANE STRESS VERIFICATION

Maximum membrane stress for service level B is verificated according to NC-3522 (table 3521-1).

$P_m = Max\,(P_{m1}\,;P_{m2}) \leq 1{,}1S_A$ **47,61 MPa < 151,8 MPa** **OK**

3.7. BENDING STRESS

Bending stress is caused by weight and dynamic loads.

$$P_b = \frac{W_A(X_A(A_{CV}+1) + Y_A \cdot A_{CH})}{J_A} = \qquad \textbf{173,60 MPa}$$

3.8. MAXIMUM PRIMARY MEMBRANE PLUS BENDING STRESS

Principal stresses according to Mohr's circle

$$(P_m + P_b)_1 = \frac{S_T + S_L + S_B}{2} + \sqrt{\left(\frac{S_T - S_L - S_B}{2}\right)^2 + t_t^2} = \qquad \textbf{220,66 MPa}$$

$$(P_m + P_b)_2 = \frac{S_T + S_L + S_B}{2} - \sqrt{\left(\frac{S_T - S_L - S_B}{2}\right)^2 + t_t^2} = \qquad \textbf{4,13 MPa}$$

3.9. MAXIMUM PRIMARY MEMBRANE PLUS BENDING STRESS VERIFICATION

Maximum primary membrane plus bending stress for service level B is verificated according to NC-3522 table (3521-1).

$(P_m + P_b) = max\,((P_m + P_b)_{1\,;\,2}) \leq 1{,}65S_A$ **220,66 MPa < 227,7 MPa** **OK**

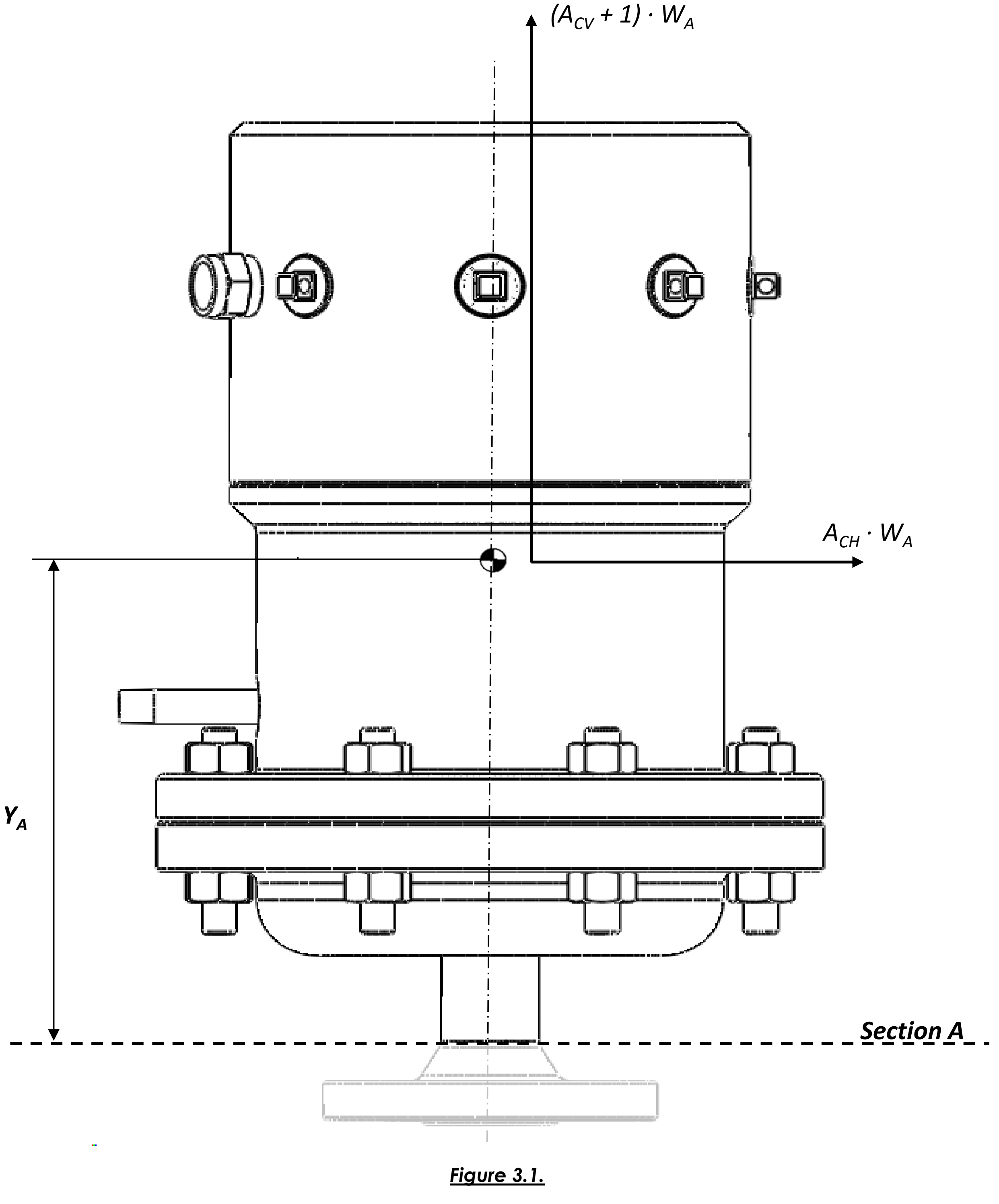


Figure 3.1.

Chapter 4

Body/lowr bonnet flange analysis

4. BODY/LOWER BONNET FLANGE ANALYSIS

Body adaptor flange analysis is verified according to ASME III Div. 1, Appendix XI.

General data

W_B	*Weight of extended mass above secion B-B*	*410,00 N*
X_B	*Combined center of gravity*	*0,00 mm*
Y_B	*Combined center of gravity*	*153,00 mm*
A_{cv}	*Vertical acceleration*	*6,00 g*
A_{cH}	*Horizontal acceleration*	*8,49 g*
G	*Medium diameter of gasket*	*150,00 mm*
P	*Design pressure*	*1,90 MPa*
N	*Gasket width (Table XI-3221.1.2)*	*0,00 mm*
b_o	*Seating gasket width (Tabla XI-3221.1.2)*	*0,00 mm*
b	*Efective width (Table XI-3221.1.2)*	*0,00 mm*
m	*Gasket factor (Table XI-3221.1)*	*0,00*
y	*Constant stress (Table XI-3221.1)*	*0,00 MPa*
S_{bB}	*Bolting allowable stress at design temperature*	*147,00 MPa*
S_{aB}	*Bolting allowable stress at room temperature*	*147,00 MPa*
n_B	*Quantity of bolts*	*8,00*
M_n	*Bolt diameter*	*12,70 mm*
A_{rB}	*Bolt stress area*	*91,55* mm^2
A_{bB}	*Total stress area of bolts*	*732,40* mm^2
B	*Bonnet inner diameter*	*33,00 mm*
A	*Bonnet outer diameter*	*250,00 mm*
K	*Diameters ratio*	*7,58*
R	*Distance between center of bolts and neck of flange*	*22,50 mm*
g_1	*Maximum neck thickness*	*13,50 mm*
C	*Bolts center diameter*	*220,00 mm*
g_0	*Minimum neck thickness*	*13,50 mm*
h	*Vertex length*	*0,00 mm*
h_0	h_o *factor*	*21,11 mm*
F	*F factor in fig XI-3240-2*	*0,91*
t	*Flange thickness*	*20,00 mm*
T	*T factor in fig XI 3240-1*	*0,66*
U	*U factor in fig XI 3240-1*	*0,97*
V	*V factor in fig XI 3240-3*	*0,55*
S_{fo}	*Bonnet allowable stress at design temperature*	*138,00 MPa*
f	*f factor in fig XI-3240-6*	*1,00*
Y_1	*Y factor in fig XI 3240-1*	*0,88*
Z	*Z factor in fig XI 3240-1*	*1,04*
S_{fa}	*Bonnet allowable stress at room temperature*	*138,00 MPa*
S_B	*Allowable stress at design temperature for 6.3.3.4 and 6.3.4.1*	*147,00 MPa*
M_a	*Maximum actuator torque*	*0,00 Nmm*
E_a	*Maximum actuator thrust*	*0,00 N*

4.1. PRESSURE ON FLANGE

The Design pressure used for the calculation of ***H*** *in Appendix XI, used in the following calculations, shall be replaced by a flange design pressure* ***(P_{fd})*** *according to NC-3658.*

$P' = P_{eq} + P =$ **2,30 MPa** *[(3658.1) (b)]*

where ***P_{eq}*** *is the equivalent pressure*

$P_{eq} = max\left(\frac{8M_{fd}}{\pi G^3};\frac{16M_{FS}}{\pi G^3}\right) =$ **0,40 MPa**

with $M_{fd} = W_B \cdot (X_B \cdot (A_{CV} + 1) + Y_B \cdot A_{CH}) =$ **532281,70 Nmm**

$M_{FS} = M_a =$ **0,00 Nmm**

4.2. DESIGN CONDITIONS

4.2.1. Areas and loads on bolts

Areas and loads on bolts are calculated according to Appendix XI-3220.

A) Design conditions (XI-3221-1)

The required bolt load for the Design Conditions ***(W_{m1})*** *shall be sufficient to resist the hydrostatic end force* ***(H)*** *exerted by the Design Pressure on the area bounded by the diameter of gasket reaction, in addition, to maintain on the gasket or joint contact surface a compression load* ***(H_p)*** *which experience has shown to be sufficient to ensure a tight joint.*

$W_{m1} = H + H_p =$

$W_{m1} = \frac{\pi}{4}G^2 \cdot P' + 2 \cdot b \cdot \pi \cdot G \cdot m \cdot P =$ **40672,86 N**

B) Gasket seating conditions (XI-3221-2)

Before a tight joint can be obtained, it is necessary to seat the gasket or joint contact surface properly by applying a minimum initial load under atmospheric temperature conditions without the presence of internal pressure, which is a function of the gasket material and the effective gasket area to be seated.

The minimum initial bolt load ***(W_{m2})*** *required for this purpose shall be determined in accordance with the following equiation:*

$W_{m2} = \pi bGy =$ **0,00 N**

C) Required area and actual area of bolts (XI-3222)

The total cross-sectional area of bolts **(A_m)** *required for both the Design Conditions and gasket seating is the greater of the values for* **(A_{m1})** *and* **(A_{m2})**. *The actual total cross-sectional areas of bolts* **(A_b)** *will not be less than* **(A_m)**.

$A_{m1} = \frac{W_{M1}}{S_{bB}} =$ **276,69 mm²**

$A_{m2} = \frac{W_{M2}}{S_{aB}} =$ **0,00 mm²**

$A_m = max\,(A_{m1}\ ;A_{m2}) =$ **276,69 mm²**

Verification

$A_{bB} > A_m$ ***732,4 mm² > 276,69 mm²*** ***OK***

4.2.2. Total load of bolts to ensure the gasket (XI-3223)

For gasket seating, the total load ***(W)*** *is:*

$W = \frac{(A_m + A_{bB})S_{aB}}{2} =$ ***74167,83 N*** *[XI-3223(4)]*

4.2.3. Bending forces on flange (XI-3230)

A) By design conditions (XI-3230)

For the design conditions, the total flange moment ***(M_o)*** *is the sum of the three individual moments* ***M*** ***M_T*** *and* ***M_G*** *as defined in XI-3130.*

$M_o = M_D + M_G + M_T =$ ***1431583,02 Nmm***

where

M_D *Component of moment due to* ***(H_D)*** *and to the radial distance from the bolt circle to the circle on which the hydrostatic force acts* ***(h_D)*** *(Table XI-3230-1).*

$M_D = H_D \cdot h_D =$ ***57580,57 Nmm***

where $H_D = \frac{\pi}{4} \cdot B^2 \cdot P' =$ ***1968,57 N***

$h_D = R + \frac{g_1}{2} =$ ***29,25 mm***

M_G *Component of moment due to* ***(H_G)*** *and due to the radial distance from gasket load reaction to the bolt circle* ***(h_G)*** *(Table XI-3230-1).*

$M_G = H_G \cdot h_G =$ ***0,00 Nmm***

where $H_G = W - H = W_{m1} - \frac{\pi}{4} \cdot G^2 \cdot P' =$ ***0,00 N***

$h_G = \frac{(C - G)}{2} =$ ***35,00 mm***

M_T *Component of moment due to the difference between total hydrostatic end force and the hydrostatic end force on area inside of flange* ***(H_T)*** *and due to the radial distance from the bolt circle to the circle on which HT acts* ***(h_T)*** *(Table XI-3230-1)*

$M_T = H_T \cdot h_T =$ ***1374002,45 Nmm***

where $H_T = H - H_D = \frac{\pi}{4}(G^2 - B^2) \cdot P' =$ ***38704,29 N***

$h_T = \frac{(R + g_1 + h_G)}{2} =$ ***35,50 mm***

B) By gasket seating

$M_o' = W \cdot h_G =$ ***2595874,06 Nmm*** *[XI-3230(5)]*

4.2.4. Flange stresses

The stresses in the flange shall be determined for both the Design Conditions and gasket seatings according to XI-3240.

A) By design conditions

- Longitudinal hub stress

$S_H = \dfrac{f \cdot M_o}{L \cdot g_1^2 \cdot B} =$ **59,38 MPa** *[XI-3240 (6)]*

where $g_o = g_1$ *[XI-3130]*

$L = \dfrac{t \cdot e + 1}{T} + \dfrac{t^3}{d} =$ **4,01**

where $e = \dfrac{F}{h_o} =$ **0,04**

$d = \dfrac{U \cdot h_o \cdot g_o^2}{V} =$ **6760,47**

Verification according to XI-3250 (b)

$S_H \leq 1{,}5S_{fo}$ **59,38 MPa < 207 MPa** **OK**

- Radial stresses on flange

$S_R = \dfrac{[(1{,}33t \cdot e) + 1]M_o}{L \cdot t^2 \cdot B} =$ **58,04 MPa** *[XI-3240 (7)]*

Verification according to XI-3250 (c)

$S_R \leq S_{fo}$ **58,04 MPa < 138 MPa** **OK**

- Tangential stresses on flange

$S_T = \dfrac{Y_1 \cdot M_o}{t^2 \cdot B} - Z \cdot S_R =$ **35,31 MPa** *[XI-3240 (8)]*

Verification according to XI-3250 (d)

$S_T \leq S_{fo}$ **35,31 MPa < 138 MPa** **OK**

- Maximum of medium stresses

Verification according to XI-3250 (e)

$\dfrac{(S_H + S_R)}{2} \leq S_{fo}$ **58,71 MPa < 138 MPa** **OK**

$\dfrac{(S_H + S_T)}{2} \leq S_{fo}$ **47,35 MPa < 138 MPa** **OK**

B) By gasket seating

- Longitudinal hub stresses

$$S'_H = \frac{f \cdot M'_o}{L \cdot g_1^2 \cdot B} =$$ ***107,67 MPa*** *[XI-3240 (6)]*

Verification according to XI-3250 (b)

$S_H' \leq 1{,}5S_{fa}$ ***107,67 MPa < 207 MPa*** ***OK***

- Radial stresses on flange

$$S'_R = \frac{[(1{,}33t \cdot e) + 1]M'_o}{L \cdot t^2 \cdot B} =$$ ***105,25 MPa***

Verification according to XI-3250 (c)

$S_R' \leq S_{fa}$ ***105,25 MPa < 138 MPa*** ***OK***

- Tangential stresses on flange

$$S'_T = \frac{Y_1 \cdot M'_o}{t^2 \cdot B} - Z \cdot S'_R =$$ ***64,03 MPa***

Verification according to XI-3250 (d)

$S_T' \leq S_{fa}$ ***64,03 MPa < 138 MPa*** ***OK***

- Maximum of medium stresses

Verification according to XI-3250 (e)

$\frac{(S'_H + S'_R)}{2} \leq S_{fa}$ ***106,46 MPa < 138 MPa*** ***OK***

$\frac{(S'_H + S'_T)}{2} \leq S_{fa}$ ***85,85 MPa < 138 MPa*** ***OK***

4.3. BODY/BONNET BOLTING ANALYSIS

Body/Bonnet bolting analysis is calculated applying equations of general theory of mechanics according to 'Shigley's Mechanical Engineering' 8th Edition. It is considered level D as stress limits for the following combination of loads:

Design pressure + Weight + Dynamic loads + Activation forces

Stress verification is performed according to NC-3522.

4.3.2. Primary Stresses

A) Stresses due to mechanical loads

$S_1 = \frac{W_M}{A_{bB}} =$ ***55,53 MPa***

$W_M = max(W_{M1}; W_{M2}) =$ ***40672,86 N***

B) Stresses due to stem thrust

$S_2 = \frac{E_a}{A_{bB}} =$ ***0,00 MPa***

C) Stresses due to dynamic loads

$S_3 = \frac{(A_{CV} + 1)W_B}{A_{bB}} =$ ***3,92 MPa***

D) Total stresses

$P_m = S_1 + S_2 + S_3 =$ ***59,45 MPa***

Verification according to NC-3522 (table 3521-1).

$P_m \leq 2S_B$ ***59,45 MPa < 294 MPa*** ***OK***

4.3.3. Bending stresses

$P_b = \frac{M}{C \cdot A_{rB}} =$ **8,81 MPa**

where

$M = W_B \cdot (X_B \cdot (A_{CV} + 1) + Y_B \cdot A_{CH}) =$ **532281,70 Nmm**

$A_{rB} = \frac{A_{bB}}{2n_B}\left[2 + \sum_{i=1}^{n}\left(1 + \cos\frac{i \cdot 360}{n_B}\right)^2\right] = \frac{3A_{bB}}{8} =$ **274,65 mm^2**

where $\left.\begin{array}{l} n = 1 \quad if \quad n_B \le 4 \\ n = 3 \quad if \quad 4 < n_B \le 8 \\ n = 5 \quad if \quad 8 < n_B \le 12 \end{array}\right\}$ **n = 3**

4.3.4. Maximum primary stress plus bending stress

$P_m + P_b =$ **68,26 MPa**

Verification according to NC-3522 (table 3521-1).

$P_m + P_b \le 2S_B$ **68,26 MPa < 352,8 MPa** **OK**

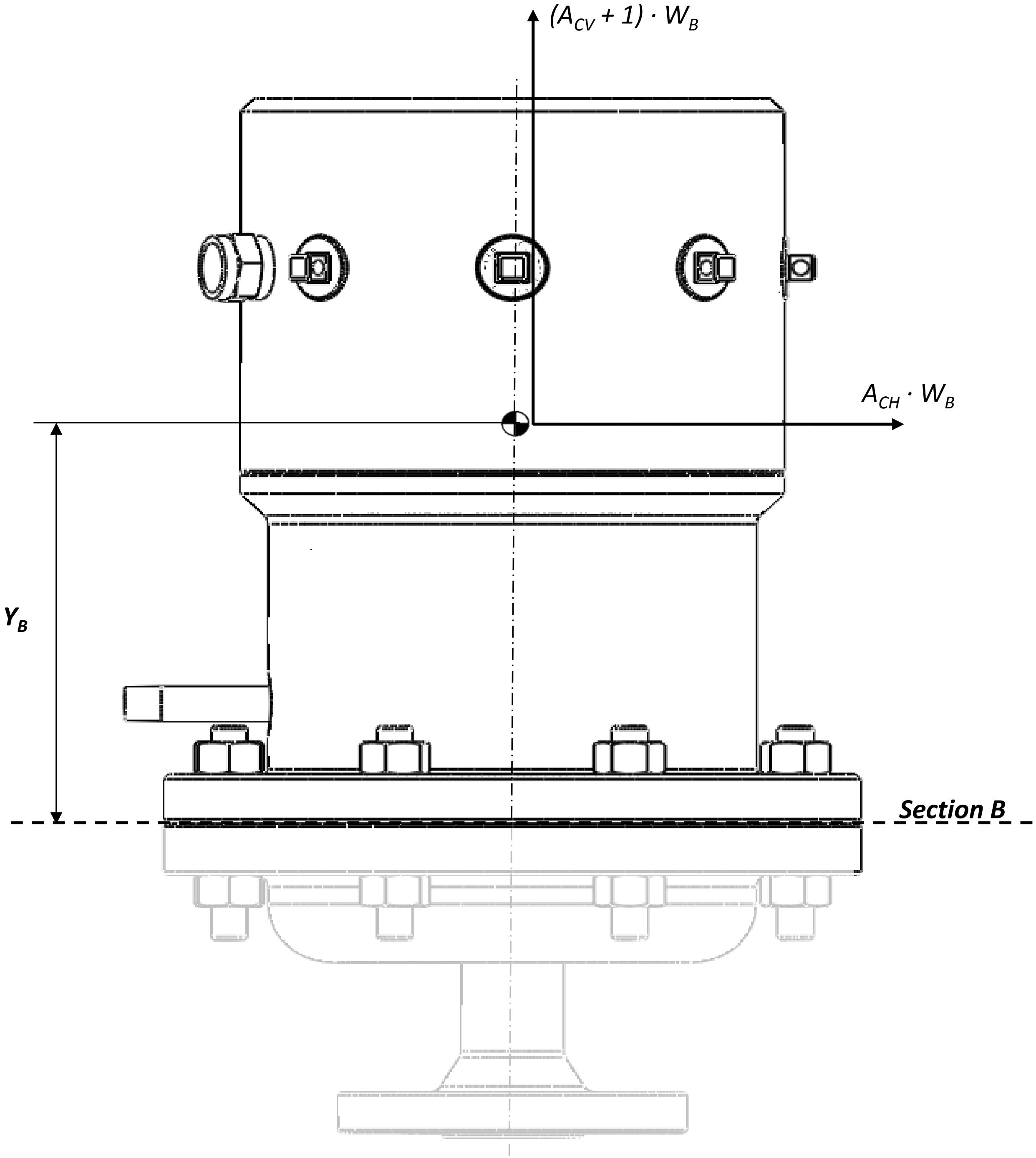


Figure 4.1.

Chapter 5

Disc calculation

5. DISC CALCULATION

Disc calculation according to ASME III Appendix A-5212 .

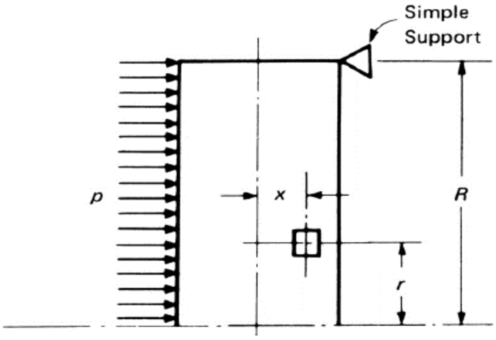
Verification according to NB-3546.2.

General data

t	*Disc thickness*	*5,00 mm*
v	*Poisson modulus*	*0,30*
P	*Design pressure*	*1,90 MPa*
R	*Seat radius*	*23,00 mm*
S	*Allowable disc stress at design temperature*	*285,00 MPa*

5.1. STRESS CALCULATION

*Principal stresses and deformations for the disc are given for a radial location **r** at any point **x** in cross direction.*



*- Radial bending stress **(σ_R)** [A-5212(1)]*

$$\sigma_r = P\frac{3(x)}{4t^3}\left[(3+v)(R^2-r^2)\right]$$

*- Tangential bending stress **(σ_t)** [A-5212(2)]*

$$\sigma_t = P\frac{3(x)}{4t^3}\left[(3+v)R^2-(1+3v)r^2\right]$$

For $x = t / 2$ and $r = 0$ the maximum stress is obtained and the following expresion is deduced:

$$\sigma_r = \sigma_t = 3\cdot P\cdot R^2\cdot\frac{3+v}{8\cdot t^2} = \quad \mathbf{49{,}75\ MPa}$$

Verification

$\sigma_R < 1.5\sigma$ **49,75 MPa < 427,5 MPa** **OK**

VI. References

- *ASME III Div 1 Subsection NC & NB Ed. 2007 addenda 2008*

- *ASME III Appendix XI*

- *ASME II part D*

- *ASME/ANSI B16.34*

- *Shigley's Mechanical Engineering Design, 8th Edition*

- *Assembly drawing RV-E1306*

ANNEX V

ASVAD VALVE
TESTING PROCEDURES
RESULTS

(see annex III)

ANNEX VI

FMEA TABLE

ASVAD VALVE FMEA TABLE

ITEM	COMPONENT	FAILURE MODE	EFECT	DETECTION	PROBABILITY	CONSEQUENCES
5	Medium body	Breakage	Leaks	Alarm to operator	Unlikely low	**Despresurization**
25	Lower body	Breakage	Leaks	Alarm to operator	Unlikely low	**Despresurization**
70	Main gasket	Breakage/ deformation	Leaks	Alarm to operator	Unlikely low	**Despresurization**
1047	Main obturator	Breakage/ deformation	Leaks	Alarm to operator	Unlikely low	**Despresurization**
173	Inlet flange	Breakage/ deformation	Leaks	Alarm to operator	Unlikely low	**Despresurization**
330	Lower body gasket	Breakage/ deformation	Leaks	Alarm to operator	Very low	**Despresurization**
375/380	Bolts / Nuts	Breakage /lossenes	Leaks	Alarm to operator	Very low	**Despresurization**
5	Medium body	Breakage	Fail to open	Visual/Test	Unlikely low	No venting
177	Spring container	Breakage	Fail to open	Visual/Test	Unlikely low	No venting
931	Medium cilinder	Breakage/ deformation	Fail to open	Visual/Test	Unlikely low	No venting
1047	Main obturator	Breakage/ deformation	Fail to open	Visual/Test	Very low	No venting
1047	Main obturator	Blockage	Fail to open	Visual/Test	Very low	No venting
1884	Adjustment disk	Breakage/ deformation	Fail to open	Visual/Test	Very low	No venting
1887	Main spring	Breakage/ deformation	Fail to open	Visual/Test	Unlikely low	No venting
186/208	Casings	Blockage	Fail to open	Visual/Test	Unlikely low	No venting
1882	Closing Piston	Blockage in sup.pos.	Piston fails to close	Visual/Test	Unlikely low	No venting
1882	Closing Piston	Semi-Blockage	Piston fails to close	Visual/Test	Very low	Opening deviations
1883	Closing cilinder	Breakage / Blockage	Piston fails to close	Visual/Test	Unlikely low	Opening deviations
1886	Closing spring	Breakage/ deformation	Piston fails to close	Visual/Test	Very low	Opening deviations
1889-1890	Closing Piston gasket	Breakage/ deformation	Piston fails to close	Visual/Test	Very low	Opening deviations
1898	Inlet pipe	Breakage/ deformation	Piston fails to close	Visual/Test	Unlikely low	none
294	Inner gasket.	Breakage/ deformation	Leaks	Visual	Unlikely low	none
1881	Opening Piston	Breakage / Blockage	Piston fails to open	Visual/Test	Very low	none

1888	Opening Piston gasket	Breakage/ deformation	Piston fails to open	Visual/Test	Very low	none
20	Upper body	Breakage	Piston fails to open	Visual/Test	Unlikely low	none
177	Spring container	Blockage	Piston fails to open	Visual/Test	Unlikely low	none
660-1725	Plugs	Breakage/ deformation	none	Visual/Test	Unlikely low	none
331	Upper body gasket	Breakage/ deformation	none	Visual/Test	Very low	none
1895	Anti-turn guide	Breakage/ deformation	none	Visual	Unlikely low	none
1891/1896/1897	Gas Deflector	Breakage/ deformation	none	Visual	Unlikely low	none
1893/1894	Plate	Breakage/ deformation	none	Visual	Unlikely low	none

ANNEX VII

ASVAD VALVE
INSTALLATION AND OPERATION MANUAL

IOM-ASVAD r0