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BOC Motherwell Critical Valve Project Reflective Report

GROUP PROJECT (ACMA5009)

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1 Introduction

This reflective report will be looking at an ongoing project within BOC's engineering and operations sector. The Critical valve project is a task within BOC where various departments are working together to identify and create maintenance plans for valves in operation on BOC sites that are classed as critical. A critical valve is a valve that if fails would cause significant harm to personnel or lead to the total loss of product in the upstream reservoir. This reservoir could be a pressure vessel or other large containment of product.

BOC is the largest supplier of industrial/ medical gases and liquids in the UK and Ireland. BOC is a company within Linde PLC, a worldwide chemical production and supply company. BOC produces air gases (nitrogen, oxygen and argon) using cryogenic distillation. This process consists of drawing the air in via large fans, filtering out any impurities such as debris using standard filters and then filtering the air again using molecular sieves to remove any hydrocarbons and other molecular impurities that need to be removed at this stage. Once the air has been purified it is compressed and cooled down in large columns using liquid nitrogen. As the air mixture temperature starts to drop the various elements will liquify at their set boiling point. This allows the process to separate and store the various products (Kerry, 2007, p.41).

Once the products have been separated, they can be sold to customers via pipeline, this is known as the tonnage business as the product is sold by the tonne. As well as this, the product can be compressed and sold in cylinders. Lastly, if a customer needs a large amount of a product, but do not have a production plant close enough for a tonnage pipeline, they can have a pressure vessel installed onsite and BOC can bulk deliver the product as a liquid.

BOC also produce other products such as Hydrogen via steam methane reformation and speciality gases, these are customer specific gas mixtures. The critical valve project being looked at in this report will be focusing on the air separation plant in Motherwell that uses cryogenic distillation to produce oxygen and nitrogen.

2 Project Scope

This project arose from an incident on the BOC Runcorn site where a top-fill valve failed during a tanker filling operation. The valve was located on the pressure vessel and is used when loading product from a tanker into the vessel. The failure occurred between the bronze body of the valve and the stainless-steel ends of the pipework. The brazed connection was performed by the valve manufacture in 1994 and gave out in 2019 after roughly 25 years of use. The Loss of Containment (LOC) was 37.5 tonnes of liquid nitrogen out of the upstream pressure vessel. The investigation included metallurgical analysis of the brazed joint that failed and similar joints on valves from the same manufacture and period that the pipework was installed. The findings concluded that the manufacturing quality of the brazed bronze to stainless-steel connections from the mid 1990's were questionable. The brazing process was manual, and this led to widespread flaws in the connection including oxidised layers and voids in the joint (Linde PLC, 2020).

The incident at Runcorn in 2019 raised a concern within the engineering department. It was discussed that it is not clear on any documentation what valves are critical according to the definition previously stated in the introduction. This revelation led to the start of the critical valve project.

A team was assembled from process engineers and mechanical engineers to devise a process that can be easily followed by other employees, to define what valves on the site are critical and need to have scheduled maintenance tasks assigned to them if they do not already. Many of the sites that BOC owns and operates were constructed between 1950 and today. The older plants lack detailed documentation on the many process valves contained within the plant.

The process has been defined and handed over to the team being looked at in this report. The team is made up from an onsite engineer, mechanical engineer, and process engineer. The scope of this team's project is to follow the defined process and look for any improvements that can be made. This is to be done by completing a critical valve study on the BOC Motherwell plant in Glasgow Scotland.

The Motherwell production plant was first commissioned around the year 2000 and was design to produce nitrogen and oxygen for the local steel works plants. Since opening the site has undergone changes as the steel works are no longer in operation. Management made the decision to keep the plant but use it has a logistical distribution and back up plant. This means it runs a scheduled on/ off operation. Unlike other BOC air separation plants it does not run 24/7, instead it can be run for a few weeks and then is shut down for a few weeks. This is all dependant on customer demands.

This plant was selected as it is one of the newer plants and the valves should be well documented, this will make the whole process smoother for this specific site.

At the time of the project the plant contains a GOX 3000 Air Separation Unit (ASU), a 600 TPD nitrogen liquefier and storage for both the oxygen and Nitrogen.

The nitrogen storage on the plant consists of 2 large pressure vessels that store 2156 tonnes of liquid nitrogen totalling 4312 tonnes stored on the site. The oxygen storage on the plant is split across 6 pressure vessels each able to store 288 tonnes totalling around 1730 tonnes of liquid oxygen.

The ASU produces more nitrogen compared to oxygen due to the make up of the air being around 79% nitrogen to 21% oxygen (Ramsay, 1896). Both products are then decanted into liquid bulk transport tanks and delivered to customers around the area.

Due to the complexity and safety requirements of the production and storage process there are many valves on the site but only a handful of these valves will be classed as critical.

3 Report aims

The aims of this reflective analysis are to highlight the good practices followed in this project alongside any areas that can be improved. The methodology, discussed in section 3, will be followed across all the BOC UK & Ireland production sites so any developments that can be identified at this time can only help improve the overall process and streamline the larger project.

This report will also be looking into the technology used during this project and any areas that automation could play a crucial role in the future.

Lastly the report will discuss the management of the project and how the various teams communicated and worked alongside one another.

4 Methodology

As previously mentioned, the process has been outlined by a previous project and this is documented in the BOC document PLM-11-12, this has been summarised in figure 1 (BOC, 2022).

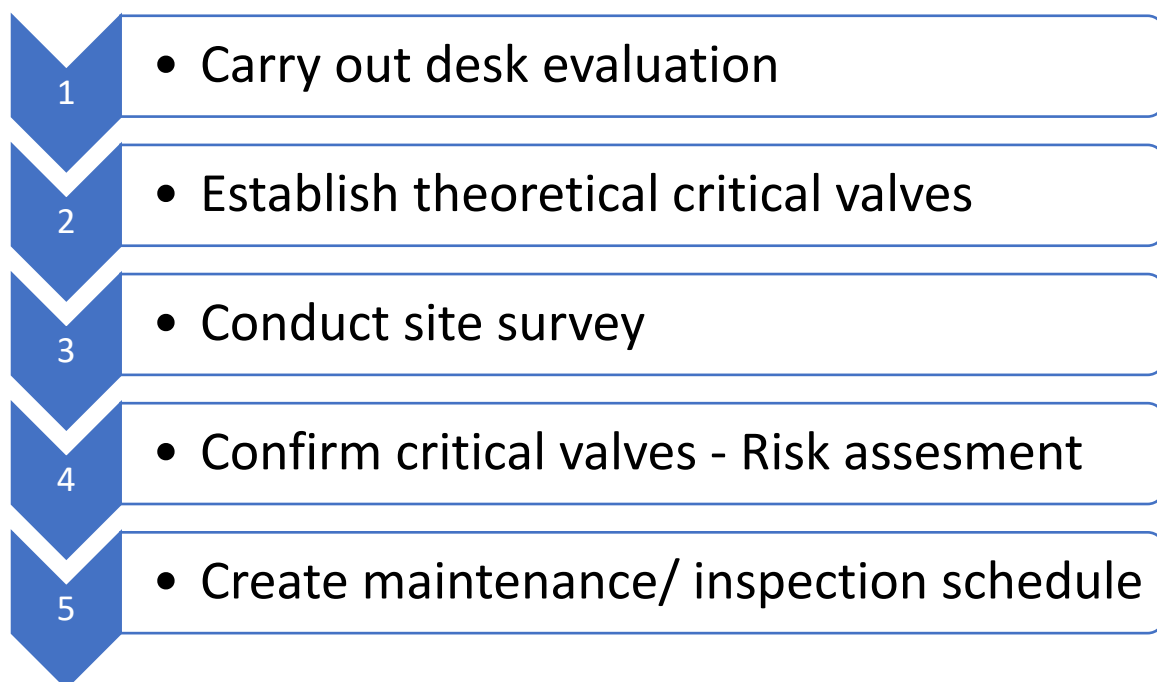


Figure 1 Project methodology

The first step in the project was to have a desk-based evaluation, this involved the mechanical and process engineers looking through the Process & Instrumentation Diagrams (P&ID's) and identifying what valves cannot be isolated if they were to fail. A P&ID is a diagram that details the hardware on site and how it is all connected, it shows pipework connection alongside signal connections via wires for instrumentation such as pressure indicators and temperature indicators. This was done using Microsoft Teams and highlighting the PDF documents.

These valves were then put through the critical valve assessment tool created by the process engineering department. The tool is an excel spreadsheet that allows the user to insert the valve details such as, valve size, valve type, valve location, operation frequency, substance the valve contains, upstream reservoir of the valve, normal operating pressure and if the valve is in liquid or vapour service. These inputs allow the tool to determine if the valve is theoretically critical or not.

With the output from the previous step a site survey could be conducted. The purpose of the site survey was to identify and document the valves onsite. This included taking pictures and an initial visual inspection of the valve. The surveyor looked and noted down the valve connections for example, flanged, welded, brazed or screwed. They also be looked for any signs of wear and tear such as rusting and mechanical failures such as cracks and pitting. The engineers also looked at the valve surrounding and noted down the location of the valve as this would come into question during the risk assessment section.

This information was then stored in a shared folder that included any images taken on site and the excel file with the critical valve assessment calculations for each valve.

The previous tasks have all been carried out and the next step is to take all the information from the previous tasks and conduct a risk assessment for each of the theoretically critical valves, the risk assessment will include discussions around the valve usage and finding from the survey.

Once the risk assessment has been conducted the valve should be classed as critical or non-critical. All the critical valves will then have an SAP maintenance task assigned to them. SAP is the market leader in enterprise application software and is widely used in all industries (SAP, 2023). BOC use SAP for a range of activities such stock control, customer order schedules and regarding this project the onsite maintenance procedures and scheduling for onsite equipment.

A Gantt chart can be seen in appendix 1 that outlines the key dates for the Motherwell site project. As can be seen in appendix 1 the project is planned to run from January to the end of June 2023. There are large gapes in the project timeline as this is being

run alongside other work commitments. As of the date of writing this report (01-05-23) the project is in phase 4 "Risk assessment".

5 Analysis

5.1 Desk evaluation

The initial stage of the project as laid out in the process specification PLM-11-12 is to identify the possible critical valves by reading the Process and instrumentation diagrams for the site (BOC, 2022). A critical valve will be located directly downstream from a large reservoir of product. For BOC this is going to be a Vacuum insulated tank (VIT) or the high/ low pressure column in the Air Separation Unit (ASU).

An ASU uses fractional distillation to separate the air in the atmosphere into nitrogen, argon, and oxygen. It does this by filtering the air using a molecular sieve and then cooling the air down to the specific boiling point of the various elements and then drawing this off as a gas or liquid (Daintith, J. 2008).

A P&ID is a representation of the physical plant pipework. The standards for these can vary from company to company. Figure 2 shows a very basic P&ID which includes a vessel, pipework, valves, Instrumentation controls, Information lines, tags and continuation arrows. Within BOC the P&ID's contain the same information as below just on a much larger scale. For the Motherwell site specifically, the plant is covered within around 30 A1 sized P&ID's.

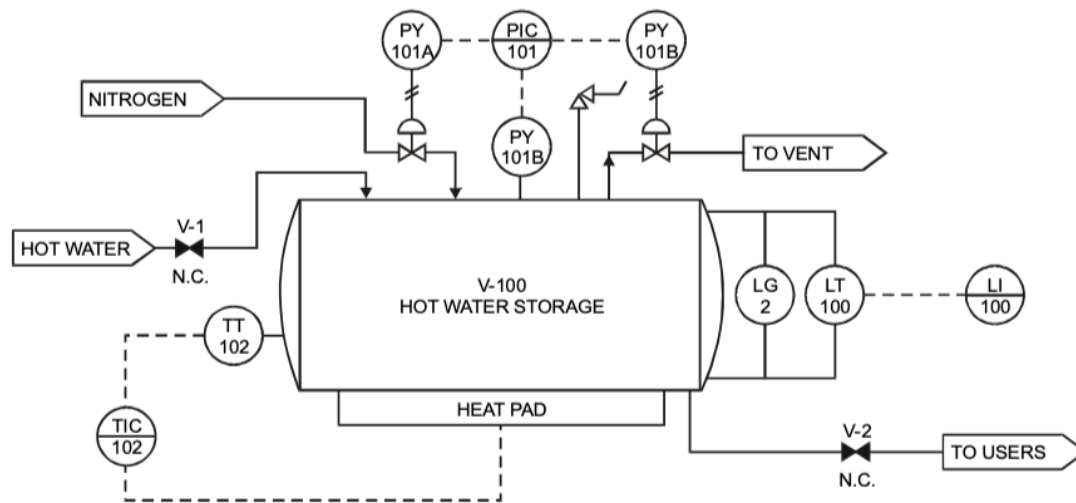


Figure 2 Example P&ID (Corso Systems, 2023).

The process of combing through the diagrams and identifying the possible critical valves is a manual process that simply involves following the pipelines from each vessel/ ASU column and highlighting the first valve that cannot be isolated. For Motherwell this was conducted by myself as the mechanical engineer, a process engineer and an onsite engineer. The reason for having three disciplines involved was so that there was a wealth of varying knowledge when discussing what valves to include in the list.

This approach has its pros and cons, an advantage to going through the P&ID manually is that it familiarises the team with the site and how it operates. This allows the team to understand what valves need to be included in the list and what ones will not be required for the next stage. A disadvantage to this approach is that the more engineering hours spent going through the

The list of valves were passed through an Excel matrix that will decide if the valve is theoretically critical or not.

The Excel file was created by the Engineering Process team and is a great tool to quickly identify if the valve in question needs to be investigated further or not. This is done by taking the values inputted by the user and completing calculations that work out if the valve was to fail how much product would be lost in a set time frame.

The file is designed to be used as a template and a copy made for each valve so that the data can be stored, and the calculations can be referred to. An improvement for the Excel file would be to use macros, a scripted automation within the file that would take the inputted valve tag number and created the required sheets automatically for the user all within the one Excel workbook. This would bring all the data into one place and make the process more streamlined. This would also help in the risk assessment and site survey stage as the engineers would only need to have one file open and would have all the valve details.

It would be a good modification to have this assessment set up in a database that allowed the engineer to input the tag numbers and then the appropriate questions were asked for the valves.

The excel file asks questions around the valve sizing and type, for some valves this information would be present on the P&ID, for some of the older valves this might not be the case. In an instance where the valve sizing or type is not clear on the P&ID an onsite engineer will be required to locate and check the valve on site. once the valve had been located the manufactures serial number or part number can be used to identify and size the valve.

5.2 Site survey

Once all the valves were put through the Excel file the project ended up with a trimmed down list of valves that consists of theoretically critical valves. The next step was to physically identify and document the state and position of the valves on site. This involved me and the onsite engineer following the P&ID and locating the valves on the Motherwell site. Some of these valves are high up on the ASU and some high up on the nitrogen storage tanks.

Figures 4 to 8 below show the position and state of some of the valves in question.



Figure 3 BOC actuated valve in Air service



Figure 4 BOC Butterfly valve in Air service



Figure 5 BOC oxygen valve



Figure 6 BOC Oxygen manual vent valve



Figure 7 BOC actuated nitrogen valve (Iced up)

The actuated butterfly valve seen in figure 3 is designed to be in air service but has to be considered as if it fails the pressure in the pipework could cause cryogenic fluid to rush down the pipe and eject from the flanged connection. This valve is situated inside the compressor building so is protected from the elements and from visual inspections looks to be in good working order. The valve seen in figure 4 is a slightly smaller version of the butterfly valve seen in figure 3, the main difference to be noted here is that the valve in figure 3 is outside and located high up on the ASU. The fact that it is outside means it is more at risk to rust and other forms of damage. It has also been noted that it is out of the way of general site activity being high up on the ASU.

The valve in figure 5 is located on one of the oxygen storage tanks and is repeated on all 6 tanks. The valve topwork, the actuator and sensors, are covered in a blue bag to

protect them from rain and other natural damaging compounds such as bird droppings. The valve body cannot be seen from a simple inspection as it is buried within the lagging on the pipework. The lagging insulate the cryogenic oxygen within the pipework and prevents energy being lost due to evaporation and stops the formation of ice build-up. The lack of ice build-up gives indication that the valve is still operating as designed.

Figure 6 is a small vent valve that is not insulated or actuated in any way. This manual valve is in the possible critical valve list as even though during normal operation it is not a wetted component, meaning it is not in service or in contact with any fluid, during filling it is in service and will be holding back the tank's contents for the short time the tanker is filling. Due to this it must be considered and evaluated alongside the other valves.

Figure 7 shows a low point of view image of an actuated ball valve that is essential to the storage tank operation. There are two of these valves one on each storage tank and they are the first valve in line with the storage tank meaning if it failed or broke off the full contents of the tank would be at risk. As can be seen this valve is enclosed in a cold box, a cold box is an insulated and sealed box that is designed to prevent energy loss and icing of the valve. Even though it looks like the cold box has failed this is not the case. The cold box is operating correctly, and this is not an unexpected amount of ice build-up.

During the site survey all parties always wore the correct personal protective equipment (PPE) and obeyed by the site rules and regulations. The PPE included cryogenic gloves, steel toe capped boots, safety glasses, hard hat and site overalls.

When locating and documenting the valves myself and the onsite engineer would take images of the valves and the location, they were in. We also had a printout list that was created for each valve and we would note down any comments for each valve such as if the valve was excessively iced up or in poor condition. Some valves would be wrapped in weather protection bags. This stops the elements damaging any sensitive hardware such as solenoids or other instrument controls. In these instances, the bag would be removed so that an inspection can be undertaken.

If this system was loaded to a database, the print out list could be auto generated or even digitized on a tablet/ smart phone.

5.3 Risk assessment

The next stage of the project is to conduct a risk assessment for each of the valves and decide if they are critical or not due to the original Excel assessment, its location on site and how often people are around it. At the time of this report being written the project is about to start this stage. In this stage of the project all the evidence collected for each valve both theoretical and physical will be discussed with a panel of employees ranging from site management, mechanical and process engineering. The site landlord has the final say on the risk assessment but will take guidance from the mechanical and process engineers. The consequences of the valves failing versus the

probability of failure will be evaluated and discussed in detail. Each valve will be given a score on the risk matrix and maintenance tasks will then be produced from this. The maintenance tasks can range from preventative maintenance to visual inspections. In case of preventative maintenance this could include actions such as replacing the valve stem or the valve seat.

6 Team communication

There are various teams involved in this project all with their own priorities and other workloads. The project team is also made up from people working onsite in the head office and working from home, due to this the team meetings are mainly held over Microsoft Teams. Microsoft Teams is a Microsoft product that allows video call meetings to be hosted remotely and allows features such as screen sharing so that all the participants of the meeting can be looking at the same thing on screen. The use of Microsoft Teams also allows meetings to be help around everyone's time schedules as there is no need to travel between meetings.

The team was structured so that the onsite engineer was the team leader and took responsibility for time management and running the project. Myself, as mechanical support, and another employee, as process engineering support were consulted when needed and required by the team lead. An example of this is when the onsite engineer could not locate the size of the valve picture in figure 7 on P&ID, I, as the mechanical support located the assembly drawing for the nitrogen storage vessel and then located the valve specification. This specification detailed the valve size and operating conditions.

Prior to the project officially starting the project team members held a kick off meeting to explain the expected goals and timeframe for the project. This is always a good idea as it allows everyone in the team to be bought up to speed on the project and what is required from the team and the responsibilities of individual members. This is also a good opportunity to spot any timeline issues such as annual leave clashes or other project commitments that may tie up someone's time during a key stage of the project.

7 Conclusion

Throughout this project the team has had to juggle other work commitments and schedules, with this in mind the project has been able to stay on track and been managed well. From the kick off meeting to the current stage the whole team have been open with communication and no one has tried to steer the project down a route with their own agenda.

One issue that can arise when leaving large time periods between team calls is that a large amount of time can be spent catching everyone back up to where the project is in the process timeline. There were a few instances of this in team calls. As this was only the second time this project had been run and the first time since the process had been outlined there were a few questions that had to be directed back to the original process experts. This caused some delays as the process expert also had other projects assigned to them and sometimes took a few days to get back this project team with answers.

Having regular scheduled calls with the process experts during this work would allow the team to collate any quires and ask them in a dedicated meeting. If there were no quires during the set time for the meeting all participants could just have the time back to catch up on other work. This would also give the process expert a time frame to come back with answers for the next scheduled call if they do not have the answer to hand during the meeting.

There is some space for automation within the site survey section of the project. It would be good to create an app that has the questions for each valve and would guide the engineer through the questions and allow them to upload the images of the valve there and then. This could all then be collated in a backend database and store the images and the information for each valve all in one place. This could also be linked to the excel file filled out in the previous desk evaluation step, this could then be taken a step further and be tied into the risk assessment section as all the data would be in one easy to access area.

This would have its draw backs as some of the sites/ areas within the sites are Ex rated meaning they are classed as an explosive atmosphere area, this would be due

to the product that is stored/ produced in the area. For example, if hydrogen is being produced the site would be Ex rated and all electronic equipment would have to be certified to be used in an explosive atmosphere. This can be overcome by wearing gas monitors or having ATEX rated electronic equipment.

Overall, the project has successfully completed the first few stages on target. Using the Motherwell site has been an effective and functional way to test the new procedure whilst also documenting the site's critical valves allowing progress for the overall project to commence.

8 References

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9 Appendix

9.1 Appendix 1

