

Plant and Asset

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Maintenance

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1. Introduction

This report aims to evaluate the current maintenance approaches of the RAS panel bender at Eurobond doors; once a critical review has been undertaken, strategies for improving the current practice can be developed and evaluated. All for the purpose of making recommendations that will improve the maintenance strategy on the machine, thus increasing its availability over time.

1.1 The equipment

Eurobond doors is a steel door manufacturer located in Cardiff, South Wales. They specialise in large steel doors with high fire ratings. Most of the components that make up the final assembly are manufactured from sheet metal in-house.

The two largest components in any door set are the “skins”, which are the front and back face of the steel door.

These components are punched from sheet steel, and the features are then folded using a “RAS up down panel bender.”



Figure 1 RAS panel bender

This machine is a specialist equipment for folding intricate profiles along the edges of large sheet metal components. The folding sequence is controlled by a CNC program written directly into the machine. An operator handles the sheet steel, places the component against the appropriate stop, as dictated by the program, and uses a pedal to initiate the bending sequence.

Once the sheet metal is in place and the pedal has been engaged, the upper beam comes down to clamp the sheet metal, and the folding arm applies the appropriate bend. The folding arm can pivot around the workpiece and fold between 0 and 120 degrees in both the up and down direction, hence “up-down panel bender”.

Figure 3 & Figure 3 are some examples of the profiles folded by the RAS at Eurobond doors.

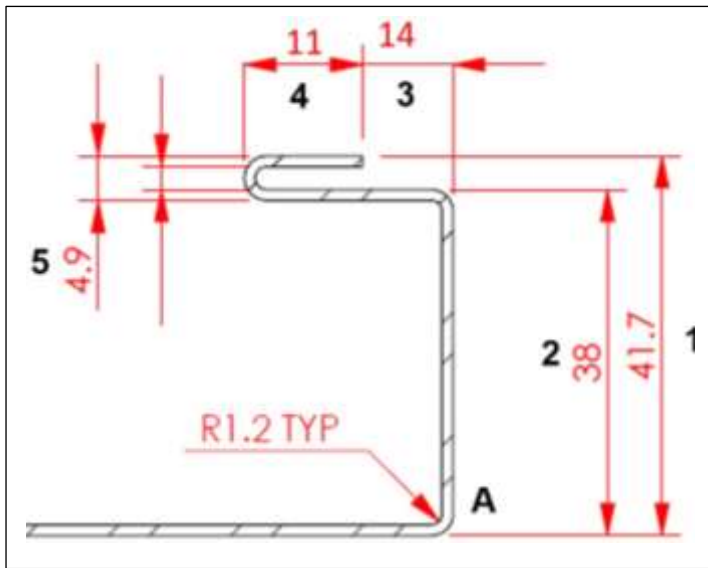


Figure 3 Face skin profile (Eurobond Doors Ltd, 2022)

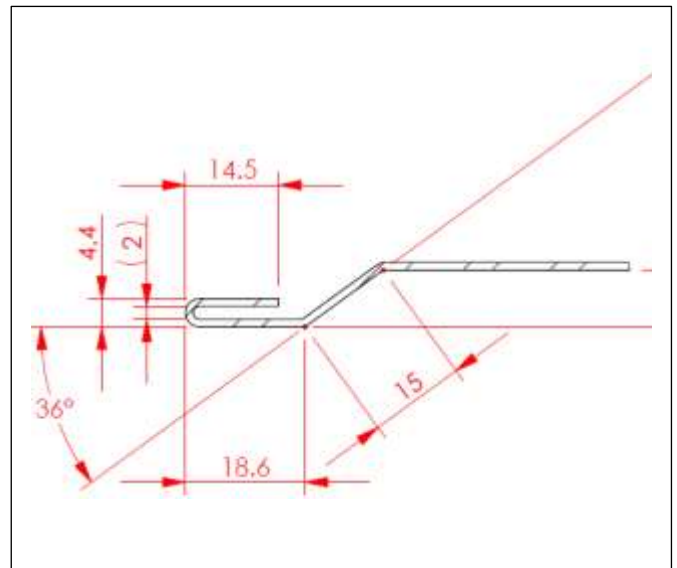


Figure 2 Astragal Profile (Eurobond Doors Ltd, 2022)

Weekly preventative maintenance is carried out in accordance with the manufacturer's recommendations. This consists of greasing moving parts and cleaning of work surfaces.

The majority of maintenance uses a reactive maintenance approach whereby parts will fail before any work is carried out on them. A typical example is that the invertors that control the bending arm will periodically break with no spares kept due to high cost.

Due to the size of the company, the maintenance department is not extensive and does not have many resources. Because of this, a large portion of maintenance is outsourced.

The first point of call is Press and Shear, which is the UK company that deals in and maintains RAS machines. However, the support received is poor due to limited engineers. Moreover, the primary engineer has fallen ill, further limiting the support we receive.

Where possible, such as inverter repair, we outsource to local company KontrolTek who specialises in electronic repairs. The inverter will typically be returned the following day; however, overnight repairs come with a high cost and are not guaranteed.

A portion of the maintenance is carried out using a condition-based strategy. Whereby the folds become less accurate or a creaking can be heard from the machine whilst performing a fold. This is an indication of the folding arm beginning to fail. Therefore, maintenance is carried out to prevent failure.

As the machine ages, it is expected that the issues and breakdowns will increase in frequency, and as support is also becoming less available, there is a long-term project in place to upgrade to an alternative piece of equipment with higher reliability and better support.

2. Critical review of current practices

the preventative maintenance that is carried out is beneficial for reducing unplanned downtime as time taken for this is factored into the production schedule. Furthermore, this maintenance should reduce the probability of break downs and lost production time. (Endrenyi, 2001)

It is possible however, that the preventative maintenance being carried out is more intensive than necessary, leading to excess costs in maintenance supplies and lost production time.

The manufacturer has recommended maintenance intervals, but since the machine only runs 10 hours per day, further investigation into the maintenance frequency may find that less maintenance is required.

The preventative maintenance only addresses certain areas of the equipment. Areas that are prone to problems are lacking in preventative maintenance.

The reactive maintenance is a cost-effective approach in the short term as only work is carried out on faulty components, meaning that maintenance is not carried out on functioning parts unnecessarily, therefore reducing labour and supply costs. However, this is not true in the long term as this method results in a high frequency of unplanned downtime, where the duration of downtime is uncertain but often lengthy. Therefore, incurring costs in lost production time.

A clear limitation of the current reactive maintenance strategy is that there are limited spares on hand therefore downtime is lengthy in the event of failure.

This strategy does not consider data associated with breakdowns such as mean time to failure, therefore, statistics that may help reduce future downtimes is not known. Instead, a data driven strategy such as predictive maintenance may be beneficial so that problem trends can be identified and addressed before downtime occurs.

The condition-based maintenance carried out is a cost-effective approach that reduces downtime by repairing components before total failure, therefore shorter maintenance periods are required and cost to repair is lower. (Prajapati, 2012)

The way condition-based maintenance is used is rudimentary however, it relies on quality control data and changing trend being identified. Which has a feedback delay to the engineering department, therefore increasing the risk of failure. Furthermore, it relies on the experience held by the operator to identify abnormalities in its operation, therefore, this is not a reliable strategy.

It may be beneficial to use specialist monitoring equipment to track data so that failure can be spotted early, resulting in an earlier intervention this may be costly in the short term but would be cost effective long term by reducing downtime and reducing repair costs. (Mobley, 2002)

3. Alternative approaches

it would be beneficial to expand the preventative maintenance to the components that are responsible for most failures which are the frequency invertors. This preventative maintenance would be outsourced to KontrolTek and can be scheduled for planned shutdowns so that no production time is lost.

It is worth noting that failure rate may briefly increase after servicing, but once running, the failure rate will decrease and the useful life of the equipment will be extended. This failure pattern

displayed in Figure 4 is known as the “bathtub curve”, where components experience a higher degree of failure in the early stages of their working life, known as “infant mortality”.

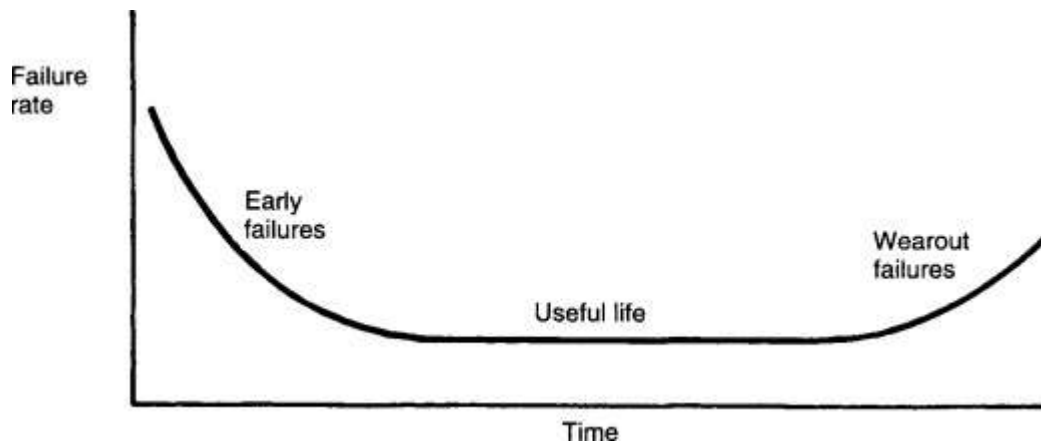


Figure 4 Bathtub curve (Smith, 2005)

The reactive maintenance strategy could be improved by holding a stock of critical parts. Since replacing parts is much faster than repairing the broken parts, downtime due to breakdowns will be greatly reduced. Once replaced, the broken parts could be repaired so that they can then be held in stock in anticipation of the next failure.

Obtaining stock of all critical parts will be costly however, therefore this should be considered against the projected savings due to reduced downtime.

The most critical parts and the most likely to fail parts should be prioritised when building a stock.

3.1 Predictive

Since the most common source of failure on this equipment is the frequency invertors, and the most common root cause is overheating due to component wear/failure. A predictive maintenance strategy may be appropriate. (Mobley, 2002)

For this, sensors can be fitted to the frequency invertors so that the temperature can be monitored. The data can be analysed either by skilled staff or monitoring software, and trends that indicate that likelihood of failure is increasing, can be identified so that maintenance can be carried out before failure occurs. (Zonta, 2020)

This method reduces downtime as maintenance can be planned, so that minimum disruption to production occurs. Furthermore, this strategy ensures that equipment operates at optimum levels for longer, therefore improving the reliability of the equipment.

The costs associated with this strategy should be considered against the projected savings, as there will be a cost to procure and maintain the sensors, as well as a potential cost for monitoring the data, as it may be complex, therefore requiring a costly solution to monitor.

As this is a new system there is limited access to data required to develop predictive model that can reliably identify failures before they occur. (Dalzochio, 2020)

4. Costs and resources

The alternative approaches to maintenance incur a cost to set up and maintain, however, they should generate a greater saving than the set-up cost, over time. Otherwise, it would not be worthwhile to implement these changes.

Before cost analysis is undertaken for these changes it is important to first understand the costs incurred from current maintenance practices, this includes equipment, maintenance, and downtime costs. This will enable the current state to be compared to a proposed future state so that the true benefit of the change can be quantified.

4.1 Mean time to failure

In the 8 years of owning the RAS, records show that inverter failure has occurred 6 times. Within an estimated operating time of 14976 hours.

Therefore, mean time to failure is 2496 hours or 62.4 weeks of production.

4.2 Mean time to repair

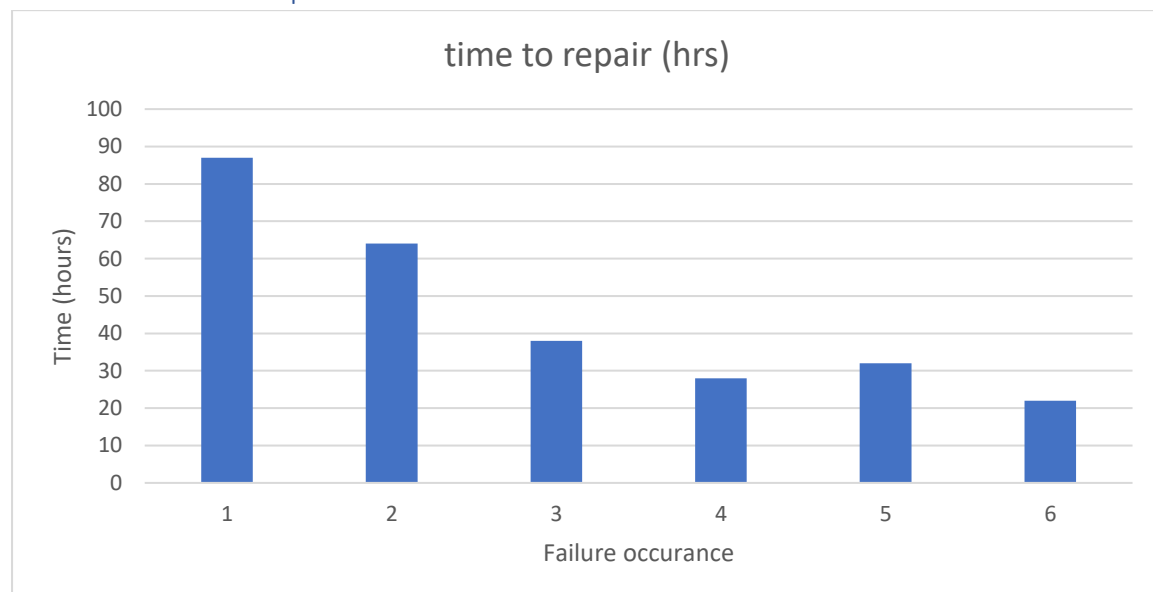


Figure 5 Time to repair by occurrence (Eurobond Doors Ltd, 2023)

Figure 5 details the time taken to complete the repair on each occurrence of the failure, the first two occurrences of failure resulted in a lengthy downtime, as the equipment was new the fault was not clear and easy to resolve, furthermore the breakdowns support from press and shear was slow in response. After the first two failures, the maintenance team has become more familiar with the machine and its faults, therefore a dramatic improvement in repair time was achieved.

The first two failures are far larger than the average due to the machine being new so they have not been included in the calculation for mean time to repair which is **30 hours** (Salonen, 2016)

4.3 Cost of breakdown

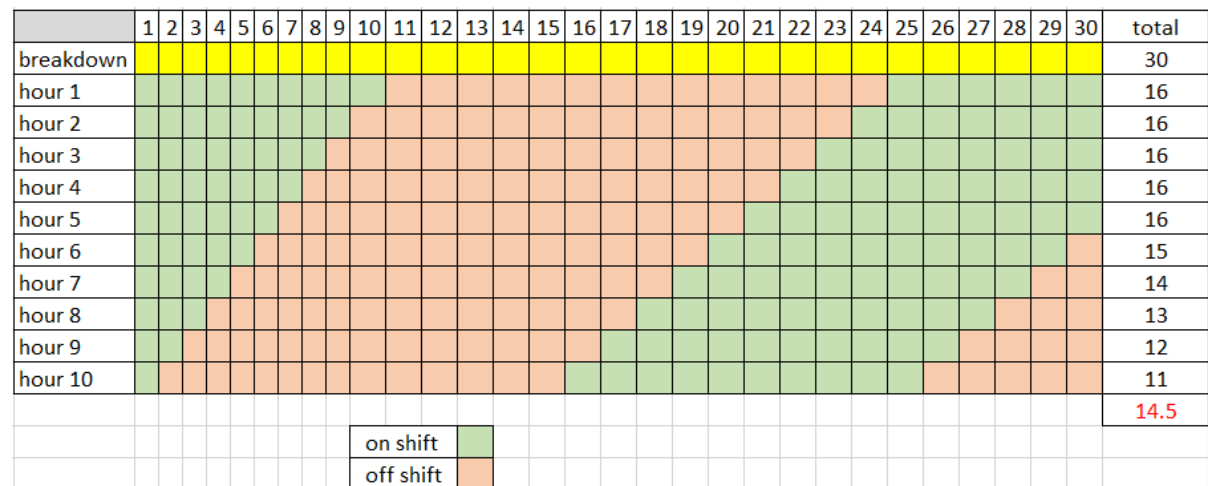


Figure 6 Average loss of production per breakdown

Assuming that the probability of failure is equal at any given hour throughout a shift, Figure 6 details how a break down in each hour of production effects actual production downtime, with an average loss of 14.5 hours of production. At a rate of **£1,650** per hour, each breakdown costs an average of **£23,925** in lost production time, with an additional **£1,200** for emergency, overnight inverter repair.

Therefore, average cost of breakdown is **£25,125**
Per annum this is equal to **£20,937.5** (Salonen, 2016)

4.5 Cost of annual inverter servicing.

KontrolTek has quoted a cost of £449 per inverter, with 8 inverters the total cost would be **£3592** per annum.

The servicing would take place in planned shutdown so no production loss will be experienced.

4.6 Cost of spares

The cost to purchase spare invertors is £2218.61 per inverter, there are 8 invertors that serve different functions, they all have the same hardware but are loaded with different parameters depending on the function.

Option 1: purchase 8 invertors with ready loaded parameters (**£17,748.88**)

Option 2: purchase 1 “blank” inverter that can be loaded with the appropriate parameters upon failure. (**£2218.61**)

Option 1 is the more risk averse approach in the sense that the invertors are guaranteed to work and the downtime upon failure would be small as the only requirement is to swap the faulty inverter out. However the cost to set up this system is high and requires large storage space.

Option 2 is a far lower set up cost however, training is required to enable the maintenance team to load parameters. There is also a higher risk of the inverter not working correctly. The downtime will be lengthier than option 1 as the time to load the correct parameters will be factored in.

4.7 Cost of predictive maintenance

The cost to purchase 12 thermocouples (8 invertors plus spares) is £290.76 (RS components, 2023)
A temperature monitoring software that can manage 10 remote connections costs £17.08
Resulting in a total set up cost of **£307.84** (Keary, 2023)

This option is low cost however requires engineer training in order to install and replace the thermocouples. Additionally, training is required to use the software to monitor the temperatures. In the event of abnormal temperature, servicing of the inverter can be arranged in a manner that minimises disruption to production and limits downtime. The cost to service may be higher than the quoted £449 however, as the servicing may need to be completed on an emergency basis, outside of normal operating hours.

Additionally, this method is not guaranteed to prevent inverter failure and unexpected breakdowns and downtime are still possible. This is particularly true in the initial stages of using the system as the indicators of failure may be subtle and require experience of breakdowns and data analysis in order to develop the skills to identify failures in advance.

This would be a notable change for the maintenance department so utilising change management strategy such as Lewin's freeze/unfreeze method would be beneficial as this gives the change the highest chance of being successful and successful over a period of time. (Burnes, 2020)

5. Recommendations

5.1 Short

purchase of blank inverter would allow a spare to be on hand immediately so that downtime can be minimised in the event of a near future failure. Estimated downtime is 6 hours costing £9900 as opposed to the current cost of breakdown of £25,125. The broken inverter can be repaired on a non-emergency basis for £449

Table 1 Short solution: cost break down per failure

Cost to procure	£2218.61
Cost of downtime	£9900
Cost to repair old inverter	£449
Total cost	£5967.61
Total saving	£12,557.39

Therefore, the set-up cost has been paid back at the first instance of breakdown and the failed inverter, once repaired, can be used as the new blank spare, so that the cost to procure is a one-time cost. Resulting in further savings in later failures.

5.2 Medium

Plan servicing of invertors for next production shutdown. No production loss is experienced. Test new invertors thoroughly throughout shut down so that any instances of infant mortality are addressed outside of production hours.

Table 2 Medium solution: savings per annum

Cost of servicing	£3592
Savings if 100% failure reduction	£17,345.5
Savings if 50% failure reduction	£6,876.75
Savings if 25% failure reduction	£1,642.38

Table 2 breaks down the projected annual savings of servicing the invertors in a planned shutdown. Even if this practice only reduces failures by 25% a small saving is still achieved.

5.3 Long

Procure predictive maintenance equipment and begin gathering data so that a predictive model can be developed to identify pre-failures before they occur.

Table 3 Long solution: savings per annum

Cost to procure	£307.84
Cost to repair invertors (non-emergency) per annum	£372.67
Savings if 100% failure reduction	£20,256.97
Savings if 50% failure reduction	£9,788.24
Savings if 25% failure reduction	£4553.87

6. Conclusion

In conclusion the current maintenance strategy used on the RAS is a basic procedure and is therefore costly as failures are common and result in large periods of downtime, through utilising alternative strategies and expanding the current protocols to cover more critical components, noteworthy savings can be achieved.

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