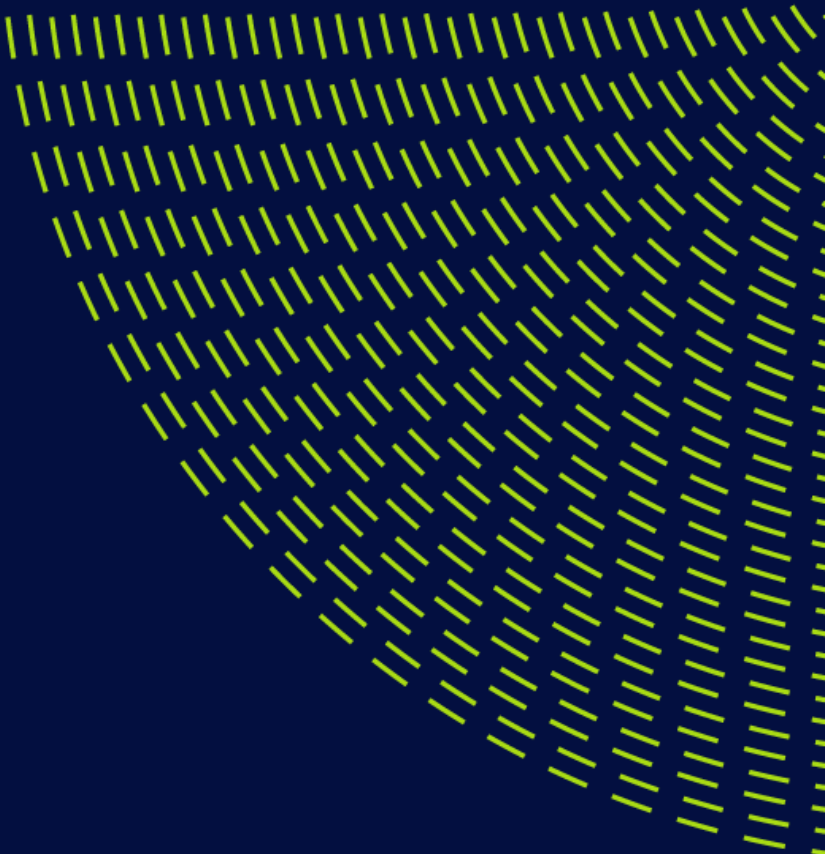




CORNWALL ENERGY RECOVERY CENTRE

Neighbourhoods Overview and Scrutiny Committee Turbine Damage and Repairs Report

Date of Incident: 22 June 2018

Date of Report: 13 September 2019

On behalf of:

Cornwall Energy Recovery

Prepared by:



recycling and recovery UK

1.0 EXECUTIVE SUMMARY

The Cornwall Energy Recovery Centre (CERC) achieved Acceptance under the Integrated Waste Management PFI Contract on 17 March 2017 and subsequently has been operated in order to provide the Services to Cornwall Council.

On 22 June 2018 the turbine tripped due to an abnormal high vibration being recorded by its control system. The turbine was removed from service and therefore the CERC stopped generating electricity from this date. An investigation was instigated into the issue and damage to the turbine was subsequently identified on 29 June 2018.

The turbine was returned to the manufacturer's workshop to conduct the necessary repairs. In parallel, a root cause investigation was instigated. Following completion of the repairs, the turbine was returned to the CERC and reinstalled on 09 September 2018. During the reinstallation it was identified that there was a potential misalignment of the turbine's exhaust duct. The turbine was therefore not restarted whilst this separate issue was investigated.

As part of the investigation into the potential exhaust duct misalignment, the CERC was shut down on 27 October 2018 to allow checks to be conducted on the duct. These checks confirmed that the turbine was not under any strain from the duct misalignment, but they identified that one of the sets of bellows within the turbine exhaust duct had been damaged causing the duct misalignment observed. Whilst this issue was investigated and the remedial works arranged, the CERC resumed waste treatment on 09 November 2018 but with the turbine remaining offline.

A replacement set of bellows was ordered and delivered to site in anticipation of the planned annual maintenance shutdown. The annual shutdown commenced on 16 February 2019. During the period of the shutdown when both lines were not operating, the replacement bellows were installed.

Following the successful completion of the annual maintenance shutdown work and the replacement bellows installation, the CERC was restarted on 13 March 2019.

Once the CERC was processing waste again, the final re-commissioning of the turbine was conducted. During the recommissioning process, on 28 March 2019, an issue with a generator protection relay was identified. The turbine recommissioning was therefore suspended until this component could be replaced. An equivalent replacement relay was identified and delivered to the CERC where it was configured for use. The recommissioning of the turbine was then completed and the CERC returned to normal operation on 12 April 2019.

Given the complex contractual situation with the Engineering, Procurement and Construction (EPC) Contractor and its supply chain, as well as the high precision, complex nature of the equipment involved, identifying the root cause of the issues is a long, complicated process and is still under investigation. Furthermore, due to the contractual implications of these investigations on the various parties, and the potential for dispute, it is not possible to include within this report such details. This report is concerned with factual information about the damage identified and repairs conducted.

Importantly, Cornwall Council has continued to receive the Services under the Waste PFI Contract throughout the duration of these issues. The design of the facility has allowed Contract Waste to continue to be accepted at the CERC and the duration of any shutdowns required to conduct the investigations and repairs have been minimised.

The cost of conducting the repairs will be fully borne by Cornwall Energy Recovery Limited (CERL) and its construction and operation subcontractors and not Cornwall Council.

The St Dennis and Nanpean Community Trust has also not suffered any loss or reduction in funding due to these issues, as CERL has continued to make the payments to the Trust based on electricity generated as though the turbine had continued to operate throughout.

2.0 PURPOSE OF THIS REPORT

Cornwall Council's waste service operations and policies fall under the remit of the Environment and Public Protection Portfolio and Neighbourhoods Overview and Scrutiny Committee. Members of this committee have requested that a formal written report is presented to them covering the following areas:

- The timeline and summary of the events that took place, from the initial failure of the turbine system through to the subsequent issues that arose during the repair and recommissioning works.
- A summary of how the issues experienced were communicated to Cornwall Council and the local community, and
- What measures have been put in place to mitigate against such failures in the future, along with any lessons learned.

3.0 BACKGROUND

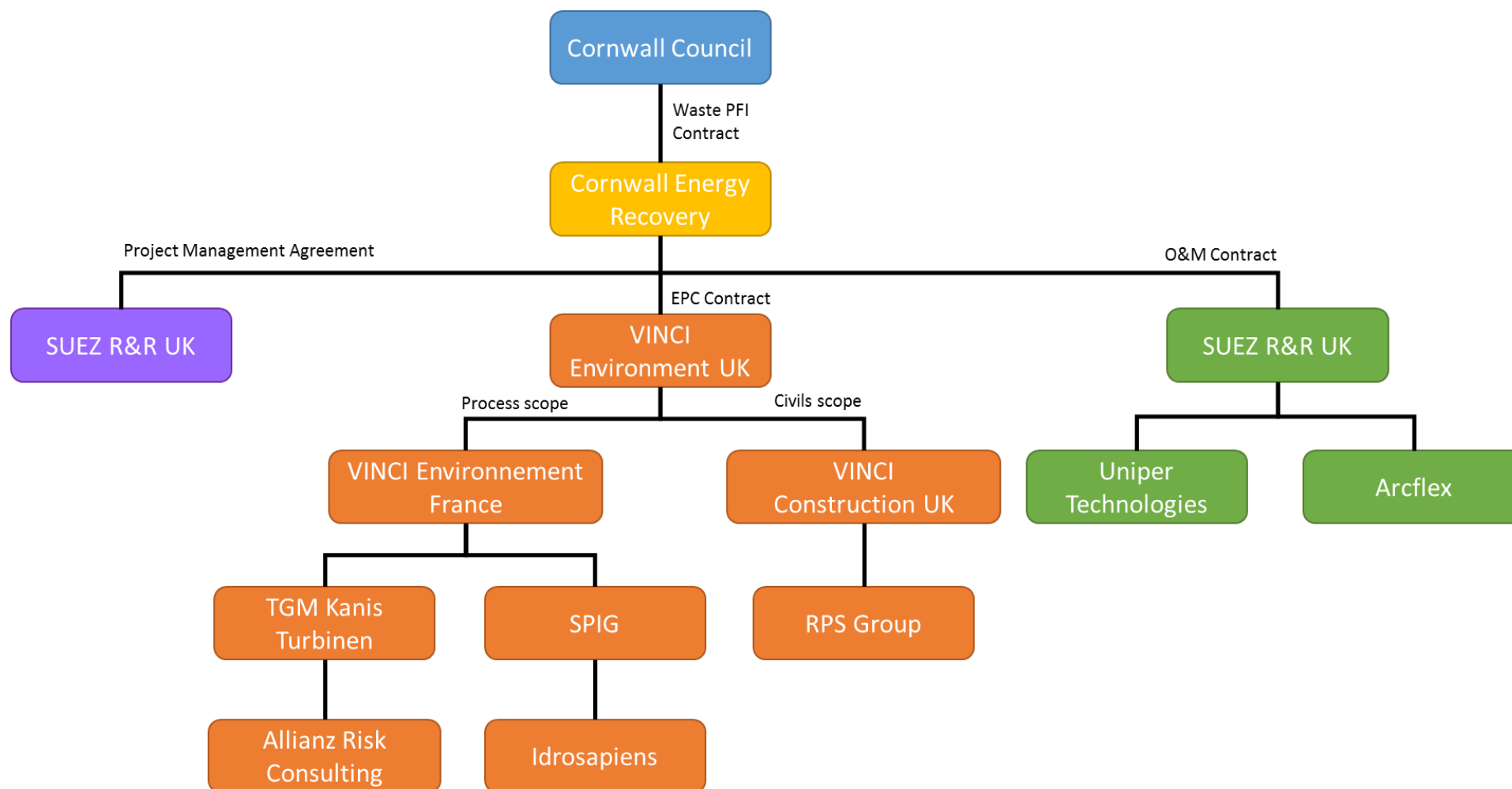
This section of the report aims to provide some background information relating to key areas of the project in order provide some context. These key areas are:

1. The different companies involved
2. The contractual relationship between the companies involved in the project
3. The arrangement of the various items of equipment and the specific components that are referenced in this report.

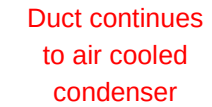
3.1 COMPANIES INVOLVED

Company	Role
Cornwall Energy Recovery Ltd (CERL)	Cornwall Council's Contractor under the Waste PFI Contract and owner of the CERC
SUEZ Recycling and Recovery UK Ltd (SUEZ)	CERL's Project Manager responsible for managing the EPC Contract
VINCI Environment UK Ltd (VEUK)	CERL's Engineering, Procurement and Construction (EPC) Contractor. The company responsible for building the CERC.
VINCI Environnement France (VEF)	The direct subcontractor of VEUK responsible for providing all process related scope of works under the EPC Contract
VINCI Construction UK Ltd (VCL)	The direct subcontractor of VEUK responsible for providing all civil and building related scope of works under the EPC Contract
TGM Kanis Turbinen GmbH (TGM)	The direct subcontractor of VEF responsible for providing the steam turbine and generator set
Allianz Risk Consulting GmbH	The specialist turbine consultant appointed by TGM to investigate the root cause of the turbine damage
SPIG S.p.A. (SPIG)	The direct subcontractor of VEF responsible for providing the air-cooled condenser and the associated connection to the turbine
Idrosapiens S.r.l.	The direct subcontractor of SPIG responsible for the design and supply of the turbine exhaust duct expansions bellows
RPS Group PLC (RPS)	The civil and building works designer and architect subcontracted to VCL.
SUEZ Recycling and Recovery UK Ltd	CERL's Operation and Maintenance (O&M) Contractor. The company responsible for operating the CERC following Acceptance.
Uniper Technologies Limited (Uniper)	Specialist engineering company appointed by the O&M Contractor to install the replacement bellows and check the turbine exhaust duct alignment
Arctrend Ltd (Arcflex)	An alternate supplier of expansion bellows appointed by the O&M Contractor to provide replacement bellows.

3.2 CONTRACT STRUCTURE



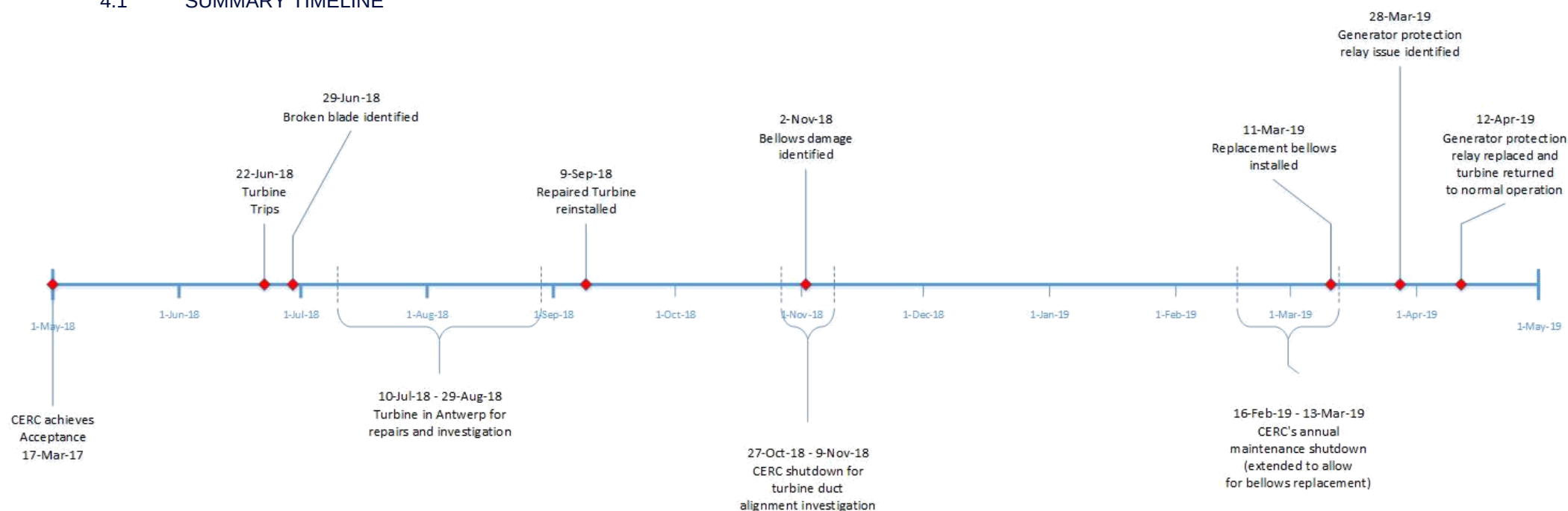
Interface point



4.0 TIMELINE AND SUMMARY OF EVENTS

Given the complex contractual situation, as well as the high precision, complex nature of the equipment and issues involved, identifying the root cause the damage identified and associated issues is a long, complicated process and is still under investigation. Furthermore, due to the contractual implications of these investigations on the various parties, and the potential for legal dispute, it is not possible to include within this report details of the ongoing investigations. This section of the report is concerned with the factual information about the damage identified, subsequent issues and the repairs conducted.

4.1 SUMMARY TIMELINE



4.2 TURBINE DAMAGE

At 11:17 on 22 June 2018 the CERC's turbine was tripped by its safety systems due to an abnormal high vibration. The CERC was at this time operating in 'Island Mode' (i.e. without the grid connection) due to Western Power Distribution conducting planned works on their network. The emergency diesel generator did not automatically switch into operation to provide power and therefore the CERC lost power, triggering a shutdown of both waste treatment lines.

The Operations and Maintenance Contractor; SUEZ recycling and recovery UK Ltd, (SUEZ O&M) informed both VINCI Environnement France (VEF) and TGM Kanis Turbinen GmbH (TGM). Due to the loss of site power and having to restart the lines it was agreed that the turbine would be restarted after the weekend when TGM could monitor the process remotely.

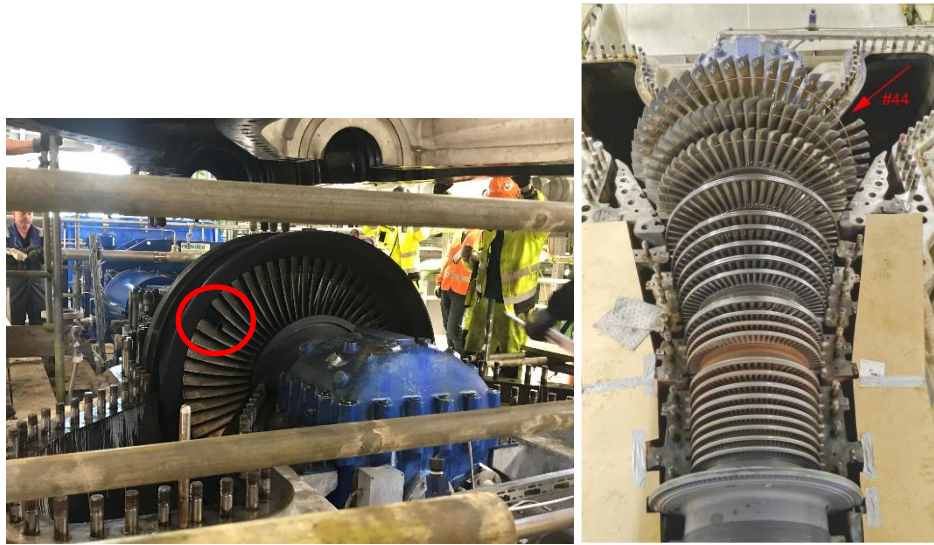
On 25 June 2018 the turbine restart was attempted with both VEF and TGM witnessing (VEF on site and TGM remotely). The turbine tripped again due to a detected high vibration. TGM agreed to travel to the CERC to investigate.

On 28 June 2018, TGM staff arrived on site and started their investigation. On 29 June 2018 an internal inspection within the turbine case using a boroscope identified that one of the blades within the final stage of the turbine appeared to be broken (Figure 1).



Figure 1: Boroscope photo of broken blade. Blades have been outlined with red dashed lines. Gap where part of the blade is missing can clearly be seen

Following the identification of the broken blade the CERC was shut down in order for SUEZ O&M to install a blanking plate (a large metal disc inserted at Flange Y in order to provide a physical barrier between the high pressure and temperature steam produced when the plant is operating and the members of staff working on the turbine and within the turbine hall). Once the blanking plate was inserted, the waste treatment lines were restarted to allow waste to continue to be treated. The turbine was then opened and the rotor examined, removed from its casing, packaged and sent to a workshop in Antwerp for repair and root cause investigation (Figure 2).



*Figure 2: (Left) View of the opened turbine showing the final stage of blades with the broken blade visible.
(Right) View of the turbine rotor upon arrival at the workshop in Antwerp showing the broken blade.*

Between 10 July and 29 August 2018 TGM and their specialist consultant (Allianz Risk Consulting GmbH) conducted a root cause investigation into the damage whilst carrying out the necessary repairs to the turbine at their facility in Antwerp.

The investigation included both non-destructive and destructive testing of the blades as well as visual inspections of the ancillary components and analysis of operating data taken from the CERC's control system. TGM's investigation identified that other blades within the final stage of the turbine had also suffered some damage (cracking), but to a smaller extent than the broken blade. The investigation also confirmed that there were no signs of any damage to the blades in the other turbine stages or the ancillary equipment. Therefore the damage was limited to the final stage of blades. A draft root cause analysis report has been shared between the parties and an updated version has been prepared but not yet released. As such, we cannot outline its conclusions.

Cornwall Energy Recovery Ltd (CERL) and its operator; SUEZ O&M, also procured some testing of the damaged blade through its own project insurers. The conclusions of this analysis were consistent with the equivalent testing conducted as part of the TGM root cause analysis.

Whilst the root cause investigation was progressing, TGM decided to manufacture a new, complete set of 56 blades in order to replace the entire final stage of the turbine rotor. These blades were produced in TGM's manufacturing facility in Brazil and shipped to the workshop in Antwerp. When these arrived TGM had already taken the decision to replace all of the blades within the final stage rather than replacing individual blades showing signs of damage/wear. These blades were fitted and the turbine rotor was balanced, packaged and returned to the CERC.

On 09 September 2018 the turbine rotor was reinstalled at the CERC. SUEZ O&M subsequently shut down the plant so that the blanking plate could be removed from Flange Y in anticipation of the recommissioning of the turbine.

4.3 DUCT MISALIGNMENT

On the 10 September 2018 the turbine exhaust duct was identified as being very slightly out of alignment (approximately 4mm vertically and approximately 5mm horizontally). The duct however was able to be reconnected and the bolts reinserted and tightened. This pulled the duct back into alignment, although a very small residual difference could still be seen (Figure 3).

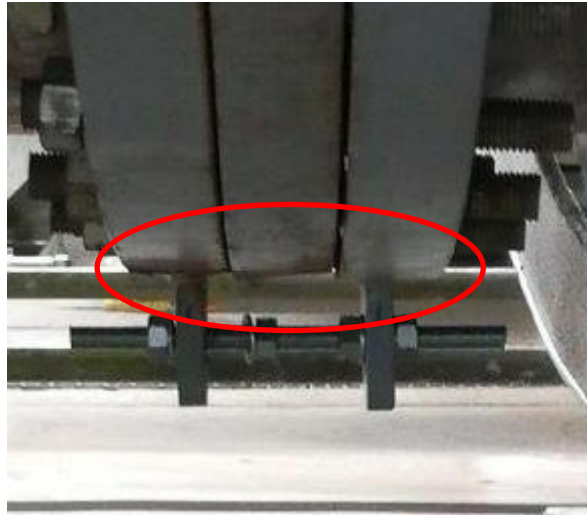


Figure 3: Flange Y with spacer ring inserted following the removal of the blanking plate. Very small alignment issue visible.

However when TGM conducted their alignment checks on the turbine they identified that the turbine was out of alignment by 0.67mm horizontally and 0.25mm vertically. This was outside of the tolerances allowed by TGM given the very high precision nature of the equipment and so the turbine alignment had to be adjusted.

TGM subsequently identified that due to the observed alignment issue at Flange Y they were concerned that the alignment would also be incorrect at the interface point for their scope of works (Flange X). They observed that such a misalignment at Flange X could result in a strain being placed on the turbine, when the design of the interface point (Flange X) is that it should be strain free. Due to this concern, TGM advised that they would only restart the turbine with an instruction to do so and that if they did, they would not be responsible for any subsequent defects that this may cause.

As a result SUEZ O&M decided on 14 September 2018 to reinsert the blanking plate therefore allowing the plant to be restarted and once more process waste whilst the duct misalignment issue was investigated.

TGM completed the cold commissioning of the re-installed turbine on 19 September 2018, however due to the duct alignment issue could not progress to hot commissioning.

In order to demonstrate to TGM that the turbine was strain free, the interface flange (Flange X) had to be opened to check movement/strains at this location. As this is the interface point between TGM's and SPIG SpA's (SPIG) scope of works, both parties needed to agree the procedure for conducting the checks, witness the checks and agree the results obtained.

SUEZ O&M appointed Uniper Technologies Limited (Uniper) to conduct the works and checks required.

All parties; CERL's Project Management Contractor; SUEZ Recycling and Recovery UK, (SUEZ PM), SUEZ O&M, Uniper, VEF, TGM and SPIG liaised over the subsequent weeks in order to agree the methodology and programme.

On 27 October 2018 the CERC was shut down in order to conduct the investigation into Flange X. On 02 November 2018 all of the above listed parties witnessed Flange X being opened by Uniper and the turbine was proven to be strain free as the turbine side of the flange did not move.



Figure 4: Movement monitoring devices attached to the TGM alignment bar confirming no movement of the turbine or gearbox when Flange X was opened.

However when Flange X was opened, the turbine exhaust duct side of the flange moved once again, this time moving approximately 16mm vertically and 19mm horizontally. The root cause of this movement was investigated and damage was identified to one of the three sets of expansion bellows (specifically bellows #3).

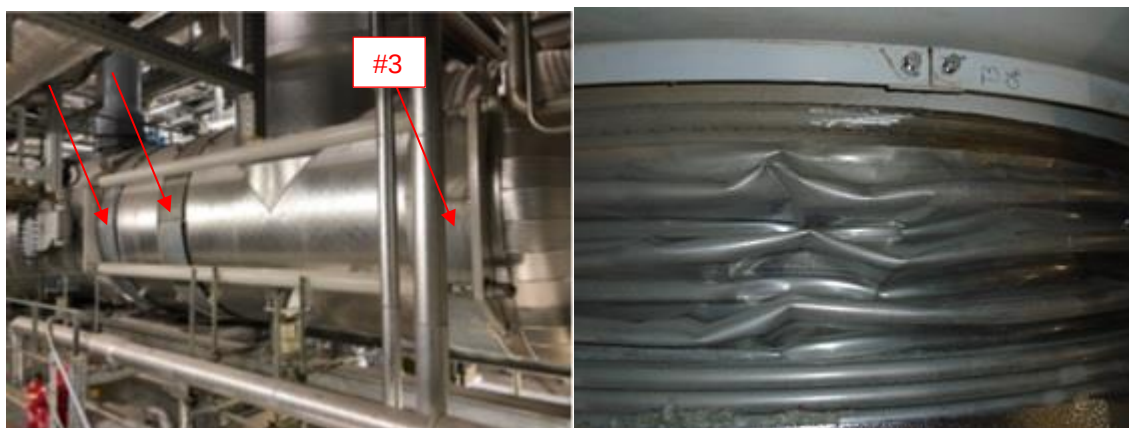


Figure 5: (Left) Turbine exhaust duct showing the three sets of expansion bellows: covered in the cladding (Right) Damage identified to expansion bellows #3 located at the base of the bellows

4.4 BELLOWS DAMAGE

Following the identification of the damage to the expansion bellows, SUEZ O&M reconnected Flange X and restarted the plant (09 November 2018) in order to continue processing waste. The turbine remained out of service with the blanking plate still in place.

Throughout November SUEZ O&M, SUEZ PM and VEF worked together to procure a replacement for the damaged bellows. Initially VEF liaised with SPIG as the subcontractor responsible for this element of the works due to all parties wanting to ensure that all warranties would remain in full effect. SPIG were also asked to provide further technical details on the design of the bellows and how they can be physically removed from their location within the turbine hall and the replacement bellows installed. This is a complex process as the bellows are 2.8m diameter circles approximately 500mm in depth and there are a number of steam pipes and walkways present in that area of the turbine hall.

SPIG's response was received on 21 November 2018, and the solutions proposed where not acceptable proposing a significant timeframe to deliver a replacement set of bellows and significant timeframe for the installation.

Both SUEZ O&M and VEF therefore sought quotations from alternate bellows manufacturers. VEF identified that the entire exhaust duct section which included the three expansion bellows was in fact subcontracted from SPIG to Idrosapiens S.r.l. (Idrosapiens). VEF therefore commenced discussions directly with Idrosapiens regarding the supply of a replacement set of bellows as this would allow the continuation of warranties. SUEZ O&M identified an alternate (UK based) manufacturer; Arctrend Ltd (who trade as Arcflex), who had a faster manufacturing and delivery timetable.

Throughout the rest of November 2018 and early December 2018, VEF worked with Idrosapiens and SUEZ O&M worked with Arcflex to confirm the design of the replacement bellows. In parallel, both VEF and SUEZ O&M started discussions with specialist installation contractors in order identify a methodology for installation and programme of works so this could be factored into the planned annual shutdown.

VEF appointed RPS Group (as the civil and building works designer) to consider access to the expansion bellows through the western wall of the turbine hall underneath the air-cooled condenser.

This was quickly identified as not a feasible solution without significant works; impacting on programme.

SUEZ O&M working with Uniper identified an installation methodology using the existing access on the eastern side of the turbine hall, with minimal adjustment to walkways and pipework. This approach was then agreed with VEF. This methodology confirmed how the expansion bellows needed to be delivered to site and therefore allowed an order to be placed with the bellows manufacturer.

VEF confirmed the order of the replacement bellows with Idrosapiens on the 19 December 2018. However Idrosapiens' bellows manufacturing facility was shutting down for the Christmas period at this point and wasn't due to reopen until 02 January 2019. Furthermore, the specific manufacturing machine for the size of bellows required was offline at that time due to an issue with a motor and a replacement was due to arrive in early January 2019. Therefore the delivery time confirmed by Idrosapiens was very close to the start of the planned annual shutdown.

Due to this programme risk, SUEZ O&M decided to order two sets of expansion bellows from Arcflex in parallel. Two sets of bellows were ordered of slightly different specifications given that the design/performance requirements were still in discussion with VEF and Idrosapiens (as the Arcflex bellows needed to be equivalent to the Idrosapiens to preserve warranties whilst accommodating that different manufacturers have slightly different processes). Arcflex confirmed that they would be able to deliver both sets of bellows in advance of the planned annual shutdown.

During January 2019 SUEZ PM, SUEZ O&M and VEF discussed the appointment of the installation contractor. Uniper were agreed to be appointed by all parties as their programme for the installation works was of a much shorter duration than VEF's proposed installation subcontractor. Uniper were therefore appointed and commenced mobilisation.

Line 1 started its annual shutdown on 16 February 2019 and Uniper therefore was able to commence their preparatory works.

The Idrosapiens bellows arrived at the CERC on 25 February 2019, a day before Line 2 was shut down. This also marked the start of the common phase of the shutdown when the whole plant was offline to allow the maintenance works to occur on the common systems (such as the turbine exhaust duct).

The damaged bellows were removed and the replacement Idrosapiens bellows were installed on 11 March 2019. TGM arrived at the CERC in order to witness the turbine exhaust duct alignment checks.

On 13 March 2019 the turbine alignment checks were completed and agreed by all parties. SUEZ O&M was then able to re-start both lines, ending the common shutdown period, having already completed the rest of the planned maintenance activities. The turbine remained offline in bypass mode (without the blanking plate installed) at this point in time as TGM still needed to complete their re-commissioning.

Due to the specialist nature of the commissioning of turbines TGM have specific named resource for this activity and so the resource must be booked in advance. TGM's commissioning engineer had been booked in advance for the 25 March 2019 based on allowing a week's contingency from the planned completion of the bellows installation works in case there had been any delays. As the bellows installation works were completed approximately on time there was then a short gap before the turbine could be re-commissioned.

TGM arrived at the CERC and commenced the hot commissioning of the turbine on 25 March 2019.

4.5 GENERATOR RELAY ISSUE

On 28 March 2019 during the re-commissioning of the turbine it was identified that one of the generator protection relays was not functioning as required. Therefore whilst the turbine had been able to generate power and export this to the National Grid, due to the nature of this fault the re-commissioning was placed on hold until a replacement protection relay could be procured.

SUEZ O&M identified a potentially equivalent relay that they had in stock at another of their facilities and arranged for this to be delivered to Cornwall. This arrived at the CERC on 01 April 2019.

TGM reviewed the potentially equivalent relay and agreed that it could be used with some re-programming. TGM's engineer subsequently re-programmed the relay, installed it and then completed the re-commissioning of the turbine on 11 April 2019. The turbine was therefore returned to normal operation from 12 April 2019.

5.0 COMMUNICATIONS SUMMARY

5.1 COMMUNICATION WITH CORNWALL COUNCIL

Throughout the period of the turbine repairs and the resolution of the subsequently identified issues members of the waste services team at Cornwall Council were kept informed. Updates were provided through a number of channels, including the SUEZ PM team, the SUEZ O&M team and SUEZ's communications team.

In general communications were made via telephone calls as this allowed the member of Cornwall Council's waste services team to ask clarifications and check understanding.

During some key periods, such as when the bellows were being replaced, updates were provided weekly. However due to the complex contractual relationships present in resolving these issues, there would often be periods where there was no substantive update, or when CERL were waiting on communications/questions/responses to make their way down and up the supply chain. During such periods the updates to Cornwall Council were less frequent. As a general principle updates were provided when relevant information was available and verified unless specifically requested otherwise by Cornwall Council.

A key point to note is that there was during these repairs (and still is) an ongoing investigation into the cause(s) and therefore the allocation of responsibility under the relevant contracts. This meant that the supply chain was particularly cautious about providing much detail on their progress, investigations or other matters. Therefore CERL, through SUEZ PM, could only provide relevant updates when such information could be obtained and verified from the supply chain. Similarly CERL, through SUEZ O&M, would often only be able to provide updates once feedback had been received from the EPC Contract side, and this often needed to be assessed by SUEZ O&M and the implications reviewed and factored into the operation of the CERC.

5.2 COMMUNICATION WITH THE LOCAL COMMUNITY

The below table summarises the communications made to the local community relating to the turbine damage and the subsequent repairs and return to use. Links have been provided to the communications where these are still available.

Date	Subject	Communication
22/06/2018	Operational update - temporary disruption to the facility's steam turbine	Email to CERC community forum ¹ and news item on SUEZ Cornwall website
05/07/2018	Operational update – fault with turbine's rotor identified during investigation. Turbine being returned to manufacturer for repairs	Email to CERC community forum and news item on SUEZ Cornwall website
11/07/2018	Operational update – lines coming back into service after being turned off to allow turbine to be removed	Email to CERC community forum and news item on SUEZ Cornwall website

¹ Please note the Community Forum is made up of local Cornwall Councillors, representatives of Parish Councils local to the CERC, a representative of the St Dennis and Nanpean Community Trust and interested members of the local community.

Date	Subject	Communication
07/09/2018	Operational update – lines to be shutdown to allow turbine to be re-installed following repairs	Email to CERC community forum and news item on SUEZ Cornwall website
24/09/2018	Community forum meeting – update given on turbine, returned and reinstalled, awaiting final checks before re-commissioning	Community forum meeting, minutes were available on SUEZ Cornwall website in 2018
29/09/2018	Press statement summarising position and confirming St Dennis and Nanpean Community Trust will receive goodwill payment	News item on SUEZ Cornwall website and issued to BBC Cornwall
26/10/2018	Operational update – lines to be shut down for final stages of re-commissioning the turbine	Email to CERC community forum and news item on SUEZ Cornwall website
11/12/2018	Operational update – damage identified to surrounding pipework following re-installation of the turbine. Repairs needed before turbine can be re-commissioned.	Email to CERC community forum and news item on SUEZ Cornwall website
28/01/2019	Community forum meeting – agenda item on turbine update, turbine re-installed, alignment issues identified, necessary work will take place during planned annual shutdown starting in February	Community forum meeting, minutes available on SUEZ Cornwall website
27/02/2019	Operational update – annual shutdown underway, in addition to routine maintenance and inspections, damaged pipework will be repaired and turbine re-commissioned.	Email to CERC community forum, news item on SUEZ Cornwall website and statement issued to BBC Cornwall
13/03/2019	Operational update – lines coming back into service following shutdown, after which turbine will be re-commissioned	Email to CERC community forum and news item on SUEZ Cornwall website
27/03/2019	Operational update – recommissioning of turbine to start this week	Email to CERC community forum and news item on SUEZ Cornwall website
16/04/2019	Operational update – turbine re-commissioning complete	Email to CERC community forum, news item on SUEZ Cornwall website and press release issued to local news outlets
20/05/2019	Community forum meeting – agenda item on turbine update, damaged pipework repaired and re-aligned, re-commissioning complete	Community forum meeting, minutes will be available on SUEZ Cornwall website in due course

6.0 MITIGATIONS IMPLEMENTED AND CURRENT STATUS

As noted in the previous sections, the root causes associated with the various damages and issues identified are still being investigated and discussed between the parties. As this discussion is ongoing and potentially subject to legal dispute we cannot provide specific details in this report about the mitigation measures implemented.

As part of the root cause analysis into the initial turbine damage, we can confirm that ten mitigation measures were identified and recommended for implementation. All of these items have been implemented at the CERC prior to the re-commissioning of the turbine and continue to be in place.

The root cause(s) associated with the duct alignment issue, bellows damage and generator protection relay failure are all still being investigated and discussed between the parties.

It is worth noting that there are now two spare sets of turbine exhaust duct expansion bellows (owned by SUEZ O&M) that are available on site should they be needed at any point in the future operation of the facility. It should also be noted that for each of the activities conducted as part of the resolution works (from inserting the blanking plate to replacement of a set of bellows) there is now a clear agreed procedure available. These two points combined mean that should there be another issue at some point in the future the time taken to resolve will be significantly shorter.

7.0 CONCLUSIONS

The turbine was returned to service on 12 April 2019 and has performed well since, generating power for export to the National Grid. The level of power generated by the turbine remains as high as it was before the damage was sustained.

CERL, through SUEZ O&M, has continued to provide the required services to Cornwall Council under the Waste PFI Contract throughout the entire period; Contract Waste has continued to be accepted at the CERC and treated (or stored and then treated). In total, only 1,278 tonnes of Contract Waste were required to be sent to landfill due to the extended common shutdown period for replacing the bellows that occurred during the 2019 annual planned maintenance shutdown. In order to mitigate the disposal of residual waste to landfill, a further 170 tonnes of Contract Waste was diverted to a third party energy recovery facility.

The cost of conducting the repairs will be fully borne by CERL and its construction and operation subcontractors and not Cornwall Council.

The St Dennis and Nanpean Community Trust have continued to receive funding as though the turbine had continued to operate throughout the entire period of the repairs.

Recommended mitigation measures arising from the root cause analysis have already been implemented to prevent reoccurrence. Should any further mitigation measures be identified as part of the ongoing investigation then these will be implemented as well.