ONE OF OUR TURBINES IS MISSING!

BY

C.M.E.A.(P) A. V. L. ROBERTS, T.ENG.(CEI), A.M.I.NUC.E., R.N.
H.M.S. Naiad

Introduction

The story told here is similar to that reported in the *Journal of Naval Engineering*, Vol. 22, No. 1, (December 1974) in the article entitled 'Needles in a Haystack', but all the circumstances are different. The two accounts show the difference between one ship with full support from a Royal Dockyard and an identical ship coping with the same problem with no support and a long way from home. It is interesting to compare the two accounts and wonder with the author why the ship without the support did the same job as the ship with full support in less than one tenth of the time. It must be admitted however that the second ship had the benefit of reading 'Needles in a Haystack' before tackling the job.

The Scenario

H.M.S. *Naiad* was operating in the Puerto Rico exercise areas at the end of a six-month period in the STANAVFORLANT Squadron. By tradition, a ship leaving the squadron steams past the remainder. As usual in close-quarters operations, special sea dutymen were closed up and the machinery brought to a higher operational state in case of any breakdown. For the previous six weeks, the T.W.L.35 auxiliary feed pump had been used in place of the T.M.F.P.35 main feed pump because the latter had suffered severe oil contamination by water through worn glands whilst running. On this occasion, as usual in these circumstances, it was decided to revert to normal operation with the T.W.L.35 auxiliary feed pump in the stand-by condition.

The Incident

The order was given to revert the main feed system to its normal main steaming condition. The T.M.F.P.35 main feed pump was run up on line feeding the boilers. The T.W.L.35 auxiliary feed pump was then stopped by operating the hand trip. To put the T.W.L.35 in the stand-by condition, the hot suction valve was shut and the cold suction valve was opened. Finally the trip was reset. At this point, the T.W.L.35 ran up and oversped; the reason being that the stop valve had not been shut!

The Effect

As is normal practice when a T.W.L. feed pump has unexpectedly tripped, an investigation was carried out to check for possible damage. A cursory glance showed that the governor link pins had sheared and the hand-trip knob had parted company with the pump, probably caused by vibration set up during the overspeed. An axial clearance reading was taken and found to be outside the limit when compared with the original reading. Some internal damage was now suspected and, in slower time, the turbine was partially de-lagged as it cooled down. After about twelve hours, the thrust collar and turbine were inspected. This revealed that the turbine had shed all its blades and shrouding. Calculations showed that some 5 kg of metal had left the turbine casing and been distributed through the exhaust system. Shortly after the disintegration of the turbine, one main-engine gland-steam controller was found to be jammed open and the

forward-evaporator exhaust-steam inlet valve could not be shut. This indicated that debris from the T.W.L.35 feed pump had already reached the extremities of the exhaust system. The danger of further, much more serious damage was imminent.

The Problems

The potential damage to other machinery was so great that the ship was diverted to Roosevelt Roads so that the machinery could be shut down and brought to a safe condition by the search for and removal of debris from the exhaust system. When the following points were considered, the task facing the M.E. department appeared to be enormous:

(*a*) The ship had been steaming at high power thus probably causing a very wide distribution of turbine blades through the exhaust system.

(*b*) The amount of metal to be retrieved was 5000 grams, in numerous very small pieces.

(*c*) There was no dockyard, F.M.G., or other ship support available in Roosevelt Roads.

(*d*) The ship had only four days to carry out the work before sailing for Devonport to meet the start date of the forthcoming refit.

(*e*) Jointing material, lagging material, nuts and bolts, and other stores were not carried onboard in sufficient quantity (especially at the end of a deployment) to support such a large undertaking.

(*f*) The necessary work comprised:

(*i*) internal inspection of:

(*a*) every exhaust valve in the system;
(*b*) the pipework each side of every exhaust valve;
(*c*) every auxiliary turbine closing pipe;
(*d*) the de-aerator;
(*e*) the evaporator steam elements and drain system;
(*f*) both main extraction pump suction pipes;
(*g*) the de-aerator extraction pump suction pipes.

(*ii*) fitting suction strainers to:

(*a*) both main extraction pumps;
(*b*) the de-aerator extraction pump;
(*c*) both element drain pumps.

The Solution

The problem of manpower was resolved by an impressive show of the ship's company's *esprit de corps:* volunteers of all rates and from every department came forward to offer their services and to work for the M.E. department. In all, about one hundred men of the ship's company became involved either directly or in support. The manpower was divided into four teams, with the M.E.O., A.M.E.O., and C.M.E.A.(P) each leading one team and the fourth smaller team being employed on all the support activities. Each of the main teams were organized into smaller groups with a senior rating or leading hand of the M.E. department directing and helping the non-technicians and technicians of other trades. As most people have used a spanner before (even if only on car maintenance) and with the technical expertise spread throughout the work force, speedy progress was made. Each team worked in shifts of eight hours with sixteen hours off, thus allowing the chance of a rest and a run ashore for everyone.

The second problem was lack of material support. The U.S. Naval Base could only supply oxygen and acetylene. The bottle connections being different from

our own, adaptors had to be manufactured on board. The Supply Officer and the Spare Gear P.O.M.E.M. travelled 80 miles to San Juan to obtain nuts, bolts, jointing, and material to manufacture strainers. The only nuts and bolts available of the correct size were stainless steel as was the perforated sheet for the strainers. The aid of the British Consul was enlisted to assist with the purchases. The cost was enough to make one aware of the advantages of carrying enough spares in the first place:

> 60 $\frac{3}{4}$-in unc. and 60 $\frac{5}{8}$-in unc. nuts and bolts cost £480, and an 8-ft by 4-ft sheet of perforated stainless steel sheet cost £110! Luckily, the U.S. Navy supplied the gas free of charge.

Having mustered all the necessary support, the proposed work was started and completed in the very short time of 54 hours. Although only one third of the estimated amount of debris was recovered during this time, the checks made and precautions taken to protect the machinery were considered to be sufficient to prevent any further damage to the machinery and to ensure a safe passage home. The main machinery was re-flashed and all systems prepared for a basin trial and an 18-hour proving trial alongside before slipping 3 days and 16 hours after arriving at Roosevelt Roads.

TABLE I—*Blading found by ship's staff at Roosevelt Roads*

Position	*Weight in grams*	
Top of de-aerator	425·2	
Fwd. evaporator, fwd. element	425·1	
Engine room to evaporator isolating valve	262·2	
Fwd. evaporator, middle element	128·0	
Atmospheric relief valve	120·5	
T.W.L.35 exhaust valve	85·2	
T.W.L.35 turbine casing	77·9	
Fwd. evaporator exhaust steam supply valve	57·0	
Exhaust steam inlet valve to de-aerator	56·7	
Main feed pump exhaust valve	56·4	
Aft. evaporator elements	28·5	
Recip. feed pump exhaust valve	28·4	
Port blower exhaust valve	28·3	
Stbd. engine gland steam control valve	28·0	
Stbd. blower exhaust valve	14·0	
De-aerator pipework	14·0	
Fwd. evaporator pipework	7·1	
Stbd. engine exhaust rejection valve	7·0	
Total	1849·5	(37·0%)

The Wash-up

A number of questions arose concerning the incident which may provoke further discussion:

(*a*) It is a well-known fact that T.W.L. feed pumps have had a long and expensive history of turbine damage due to maloperation, the built-in safety devices being inadequate to prevent this and the consequent search of exhaust systems. Is a redesign required and would it save money in the long run?

(*b*) As a temporary measure, should a strainer be fitted in the exhaust line from the T.W.L. feed pump to confine the blades to one area in the event of disintegration of the turbine? If this were done, would the turbine performance be affected unacceptably?

(*c*) Could non-technicians be employed effectively more often on large repair jobs of this nature? In this case, an original estimate of three weeks to complete the work turned into an actual elapsed time of fifty-four hours, thus avoiding a rescheduling of the ship's forthcoming refit.

Postscript

During the ensuing refit, much more debris was found in the exhaust system but none of it was in a position to do any further damage. A proportion of blading has never been found, probably because it disintegrated into a form of dust which was seen but found not possible to weigh.

TABLE II—*Blading found by dockyard during refit*

Position	*Weight in grams*
Boiler room exhaust manifold	1107·67
De-aerator	685·02
T.W.L.35 exhaust pipe	242·21
Manifold to gland steam reservoirs	32·50
Engine room exhaust range	16·25
Total	2083·65 (41·7%)

Thus the grand total of blading found was 3933·15 grams, i.e. 78·7 per cent. of the calculated total.

TABLE III—*Time-table of events*

Date	*Time*	*Event*
5 March	1600	T.W.L.35 feed pump oversped and disintegrated
6 March		Ship diverted to Roosevelt Roads
7 March	1200	Arrived in Roosevelt Roads and shut down to shore power
	1600	Commenced dismantling exhaust system
9 March	2200	Search and reassembly completed. Re-flashed to self-sustaining
10 March	1030	Basin trial
11 March	0400	Sailed from Roosevelt Roads

Comment by Ship Department

Recovery of the turbine failure was commendably rapid. The ship took a calculated risk in sailing with only one third of the debris recovered. It would be unwise for this figure to be used as a yardstick in future failures.

These T.W.L. feed pumps have a long history of effective and reliable service marred only by occasional but expensive maloperations. The most commonly reported fault is to leave the steam exhaust valve shut at start up; this results in case distortion and bearing damage. To prevent this, interlocks between the exhaust and stop valves are being developed.

The account of the incident does not give sufficient detail to determine the reason for pump overspeeding beyond the trip speed. The condition of open suction, open stop, and resetting the trip by hand is exactly the routine employed by the pump manufacturer to set and test the trip. Presumably in this case, either the trip mechanism was defective or the clearances in the pump were wrong and allowed interference between the blades and stator.

Shedding turbine blades is fortunately an infrequent occurrence. Installing a device to catch blades and metal particles in the exhaust line would degrade the pump's performance. Any strainers should be confined to points where debris is capable of causing damage, i.e. upstream of stop valves.

ARTICLES FOR THE JOURNAL

The forewords that appeared at the beginning of the first issue of *Papers on Engineering Subjects* (1920) and the first issue of the *Journal of Naval Engineering* (1947) are reprinted below. The objectives expressed in both are still basically the same today: to keep engineer officers and ratings in touch with developments in their profession and to give a wider circulation of technical information on future projects, and also to provide a medium in which the 'seagoers' can describe their experiences with equipment at sea for the benefit of others with similar equipment and of future designers.

Papers on Engineering Subjects

The object of this publication is to bring to the notice of Engineer Officers from time to time engineering information, not otherwise generally available to them, which is likely to prove of value and assistance in carrying out their official duties.

With the object of keeping Engineer Officers in touch with the developments of their profession, it is intended amongst other information to issue descriptions of and experience obtained with the latest developments of propelling and auxiliary machinery, with their appliances and particulars of materials, fuels, manufacturing methods, &c., together with the results of important trials and of Engineering Research work carried out under Admiralty direction or elsewhere.

But an equally valuable feature will be the promulgation of the particular experiences available from current practice afloat. The success of this aspect of the Papers is necessarily dependent in the main upon the co-operation of those Officers serving afloat. Engineer Officers are accordingly invited to forward for consideration contributions dealing with experience in the daily running, maintenance and repair of machinery under their supervision, which is likely to prove of general value and interest and which would not customarily be reported to the Admiralty.

(*Sgd.*) G. G. GOODWIN,
Engineer-in-Chief of the Fleet.

Journal of Naval Engineering

I am glad to be able to take this opportunity of introducing the first copy of the *Journal of Naval Engineering* which has superseded the issue of *Papers on Engineering Subjects.*

This *Journal* is the outcome of a demand from the Engineering Branch for a wider circulation of technical information and for a medium wherein our troubles on matters connected with Naval engineering may be ventilated. With this in mind we welcome correspondence, contributions and suggestions and I hope that you will help us to produce a periodical of particular value to those connected with marine, air and gunnery engineering in the Royal Navies.

I should like to express a special word of thanks to all who have helped in the past with contributions for *Papers*, and we are particularly indebted to those of other Departments who have expended much of their time for our benefit. A spirit of happy co-operation will inevitably lead to a better understanding of our respective problems.

(*Sgd.*) D. C. FORD,
Vice-Admiral (E),
Engineer-in-Chief of the Fleet.

The *Journal* is possible only because the Editor receives from Service contributors and from those concerned directly with the Service a sufficient number of articles and papers for publication. Although he receives most valued co-operation from authors unconnected with the Navy in the production of articles which are of interest to all whose profession is engineering, the *Journal* remains primarily a publication '*of* the Navy' rather than '*for* the Navy'. It is not a Ship Department publication and articles on marine, air, and weapon engineering subjects are welcome from all quarters. Engineering subjects include not only the nuts and bolts but also the personnel—their training and careers—upon whom so much depends.

The security classification of the *Journal* is 'Restricted' but, within this limit, authors may express their personal opinions and ideas on any aspect of their profession. In cases of doubt, the Editor will take the necessary steps to ensure that the classification is not infringed.

Within the same limits, letters from any reader, professionally connected or not with the Navy, are equally welcome; their contributions help greatly to broaden the field of view, pose problems, and propound ideas on naval engineering matters.

THE EDITOR.