CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 66-48

EXAMINATION OF BROKEN DAVIT SCREW FROM C.C.G.S. "SIR HUMPHREY GILBERT"

by

D.E. PARSONS AND D.A. MUNRO

PHYSICAL METALLURGY DIVISION

COPY NO. 13

JUNE 22, 1966

Mines Branch Investigation Report IR 66-48

EXAMINATION OF BROKEN DAVIT SCREW FROM C.C.G.S. "SIR HUMPHREY GILBERT"

by

D.E. Parsons* and D.A. Munro**

- - - - - -

SUMMARY OF RESULTS

Metallurgical examination of a broken boat davit screw from C.C.G.S. "Sir Humphrey Gilbert" showed that the steel was AISI-1040 steel and had been installed in the annealed (soft) condition. High-stress, low-cycle fatigue failure occurred after 50 cycles. Fatigue failure was attributed to the presence of a stress-raising (notch) at the entry to the first and last threads and to the low endurance limit of the metal in the annealed condition.

The supplier has arranged to replace all boat davit screws with liquid-quenched and tempered SPS-245 steel redesigned to provide adequate section thickness, strength, and thread radii.

* Senior Scientific Officer and ** Technician, Ferrous Metals Section, Physical Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

INTRODUCTION

On May 27, 1966, Mr. W. Harwood, Ship Repairs, Marine Services, Department of Transport, submitted a broken davit screw from C.C.G.S. "Sir Humphrey Gilbert" with the request that a metallurgical examination be carried out by the Physical Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys, to determine the cause of failure. The letter covering this enquiry (Ref. 9172-S18 (S.REP.)) from Mr. A. MacClements, Chief, Ship Repairs Division, Marine Services, requested chemical and physical tests to determine if other davit screws were similarly affected.

VISUAL EXAMINATION

The appearance of the fracture is illustrated in Figure 1. The appearance of the fracture is typical of a low-cycle, high-stress, fatigue failure located at a sharp notch coincident with the first thread. The absence of well-defined rings on the surface of the fatigue crack suggests that failure was due to a repetition of stresses of the same magnitude rather than to stresses of varying intensity.

Figure 1. Fatigue Fracture at First Thread Root of Ship-Davit-Screw. Hardness of material (R_B 92) soft annealed condition. Fatigue failure occurred at a sharp notch at the first thread in annealed AISI-1040 carbon steel.

X2-1/2

CHEMICAL ANALYSIS

The results of chemical analysis, shown in Table 1, show that the steel conforms to the chemical composition requirements of AISI-1040, electric furnace steel.

TABLE 1

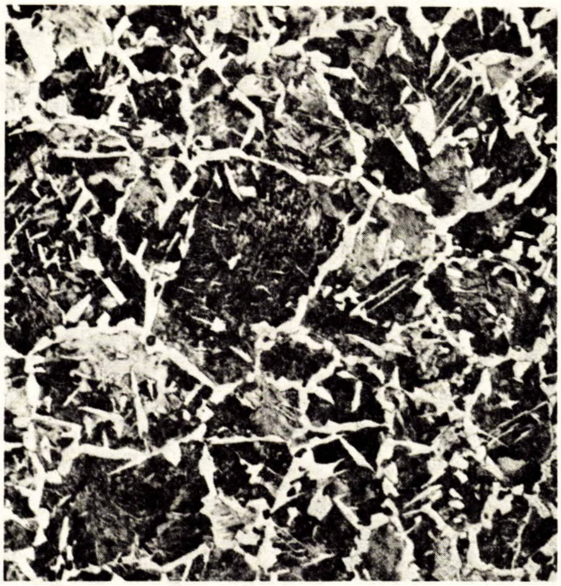
Chemical Analysis

Sample	Element (Per Cent)				
	C	Mn	Si	S	P
Failed Shaft	0.38	0.78	0.14	0.025	0.021
AISI-1040	.37/.44	.70/1.00	-	0.025 max	0.025 max

METALLOGRAPHY

The microstructure of the shaft consisted of lamellar pearlite and proeutectoid ferrite, showing that the metal was in the soft, furnace-annealed, (unhardened) condition. In the soft condition, the endurance limit in fatigue is approximately 40 kpsi (for polished bars), whereas in the liquid-quenched tempered condition at 38 R_c (BHN 352) the endurance limit should be above 80 kpsi in the absence of any stress-raiser (notch) and providing the steel is adequately protected from salt water corrosion.

Figure 2 illustrates the annealed microstructure of the failed shaft.



X100 - 2% nital etch

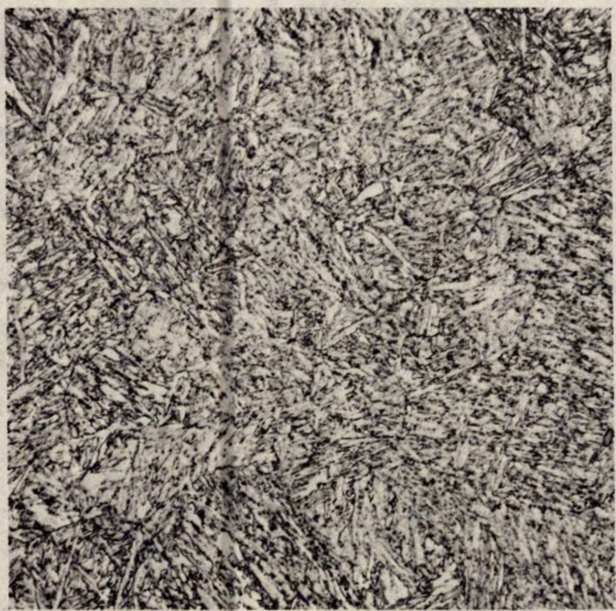
Figure 2. Microstructure of Failed Shaft. (Hardness R_B 92). The microstructure consists of fine pearlite and proeutectoid ferrite, showing that the metal is in the annealed condition.

LABORATORY HEAT TREATMENT

Figures 3 and 4 illustrate the microstructure obtained when metal from the bar was water-quenched from 1550°F (Figure 3) and when metal was water-quenched from 1550°F and tempered one hour at 1000°F (Figure 4).

X500 - 2% nital etch

Figure 3. Sample, Water-Quenched 1550°F, Rockwell C 54_c (for 1/2 in. depth).



X500 - 2% nital etch

Figure 4. Sample, Water-Quenched 1550°F, Tempered 1 hr 1000°F, R_c 30 (for 1/2 in. depth).

DISCUSSION

Failure of the shaft appears to be due to fatigue of annealed steel in the presence of a sharp fillet. No evidence of corrosion was observed on the broken shaft examined. The appearance of the fracture indicates that failure occurred after relatively few cycles and after formation of a relatively shallow (1/4 in.) circumferential crack located at a stress-raiser (sharp notch) at the entry to the first thread.

This failure renders the other davits suspect and indicates the need for modification of the design for use of stronger metal having higher endurance limit (higher safety factor) and for redesign to replace sharp notches with adequate fillets. One suitable grade of steel for replacement would be AISI-8640 used in the oil-quenched and tempered condition at Rockwell C 32-38.

CONCLUSION

(1) The shaft failed in fatigue after application of low-cycle, high but uniform stress. The metal was annealed AISI-1040 steel having relatively low endurance limit at Rockwell B 92.

(2) There was no evidence that corrosion had reduced fatigue life of the shaft.

RECOMMENDATION

Eliminate the sharp notch stress-raisers and use liquid-quenched, tempered, through-hardened steel at Rockwell 32-38. Protect the metal from corrosion and use adequate section.

DEP/DAM/bb