SUPPLEMENT No. 519

Öberg Hans:

Investigation of deformations and related loads, applied to the lug of the visor bottom lock of MV ESTONIA.

Royal Institute of Technology.

Stockholm 1996.

KUNGL
TEKNISKA
HÖGSKOLAN

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REPORT
96-03-26

The Accident Investigation Commission

Börje Stenström

Investigation of deformations and related loads, applied to the lug of the visor bottom lock of MV Estonia

An investigation was commissioned by SHK to be carried out by the Department of Solid Mechanics at KTH (the Royal Institute of Technology) in Stockholm in order to show the behaviour of the lug of the bottom lock when subjected to a combined bending and pulling force. The test was carried out by Hans Öberg, Senior Research Engineer at the Department and was witnessed by Dr. Tech. Mikael Huss and Mr. Börje Stenström on behalf of the Accident Investigation Commission.

Test specimen and loading set up

A test specimen was made in one third scale compared to the original. See **Figure 1**. It was manufactured in steel to the Swedish specification SS 2172, being approximately equivalent to the earlier St52. The specimen contained two test sections, arranged back to back. The holes for the locking bolt of diameter 28,0 mm was elongated in the longitudinal direction of the lug by machining to the length of 31.5 mm in one hole (1.) and 30.0 mm in the other (2.) in order to illustrate two different conditions of original wear of the hole. The elongations were located symmetrically around the centre of the original hole.

The loading of the specimen was made at the ends of two bolts of diameter 26.3 mm with dimensions to give an arm of momentum of 80 mm to the centre of the lug. It should however be observed that the arm of momentum decreased substantially during the test due to deformation of the holes and bending of the bolts.

Test equipment

The servohydraulic material testing machine MTS 160 kN was used. Load versus loadpoint displacement was stored in a connected PC.

Photos of the test piece were taken at different load levels, using a camera with f=50 mm at a distance of about 400 mm.

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The bending and elongation of the test piece were measured during the loading using a calliper. After testing the symmetry section of the test piece was uncovered by sawing and milling. The section geometry was measured using a coordinate measuring equipment. See **Figure 2.**

Testing

The test specimen was loaded in increments of 10 kN. It was photographed at each load level. The length of the lug and the deflection in way of the centre of the hole were measured at each step. Plastic deformation started to develop at the edges of the holes at 10 kN. Loading was continued until the deformation as measured as the angle between the stem of the lug and the bolt was about 30 degrees. This could not be determined accurately during the test as the bolts themselves showed significant bending. The testing was suspended at a load of 50 kN. Load versus loadpoint displacement is shown in **Figure 4.**

The test specimen was cut apart along its centre line in order to better show the deformation and the contours of the holes. The section of the deformed specimen is shown in **Figure 2.**

Observations

It was observed that considerable elongation had taken place in the bolt holes, being close to 1.5 mm in the test scale at mid thickness of the lug. Detailed dimensions are shown in **Figure 2.** Considerable plastic deformation had taken place at the contacting points between the bolts and the edges of the holes. Some plastic deformation was also noted on the bolts, resulting in a smoothening of the contact pressure distribution. The elongation was not accompanied by any increase of the length of the entire specimen in the bent condition.

Photos of the test set up at 0.1 kN and 50 kN respectively in **Figure 3** demonstrates the decrease of the arm of momentum due to deformations.

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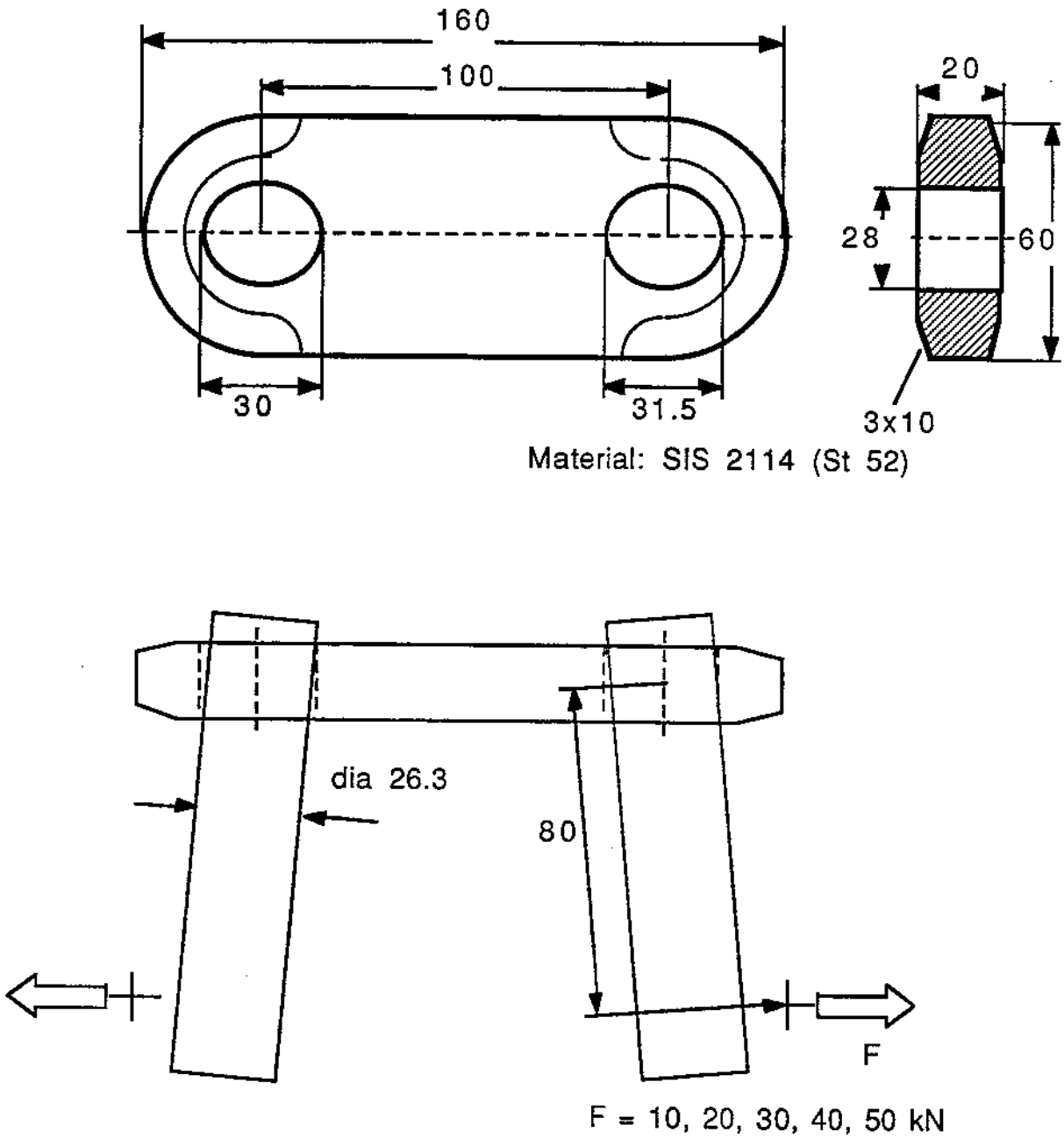


FIGURE 1 TEST SPECIMEN AND TEST ARRANGEMENT

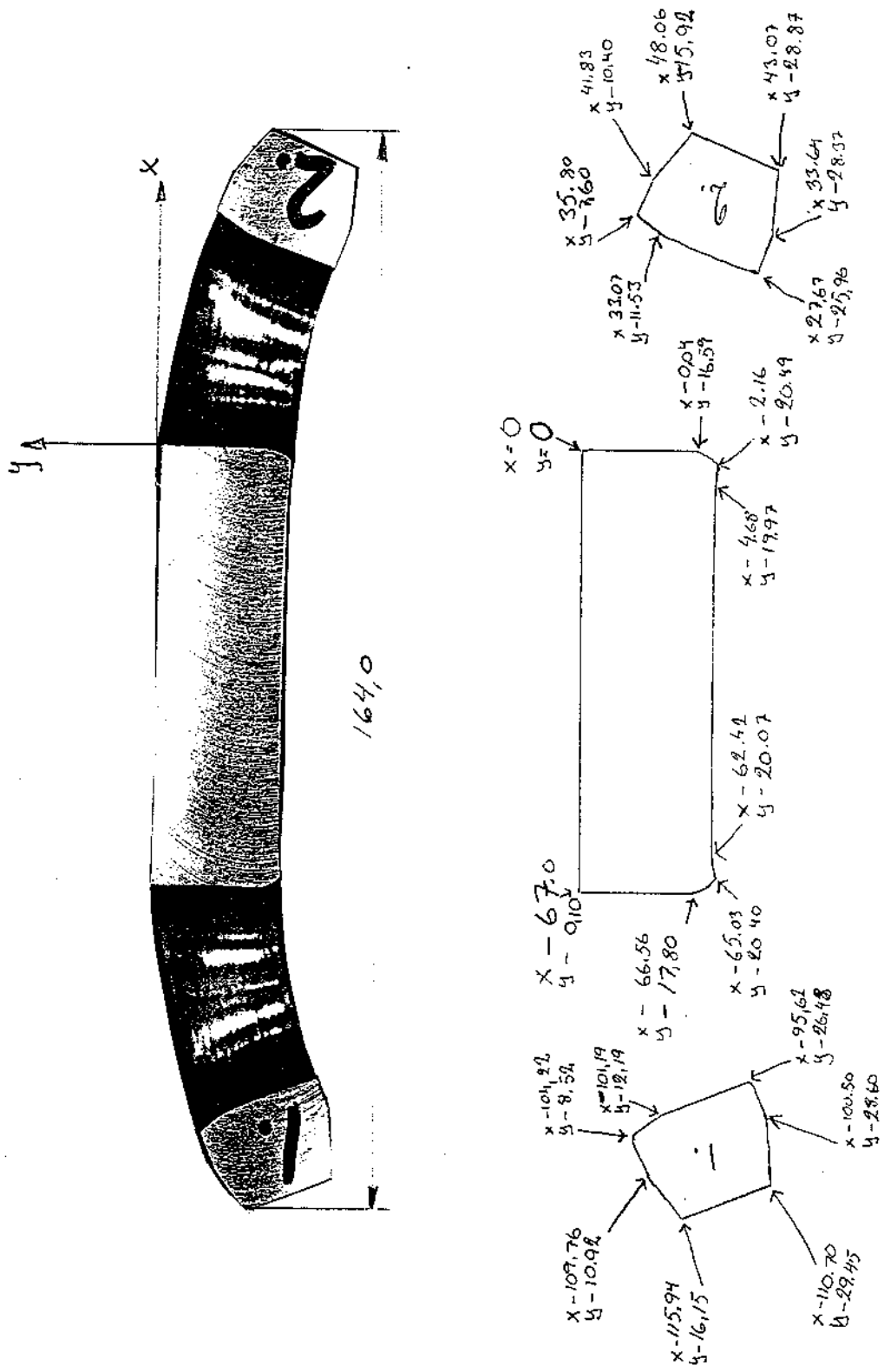
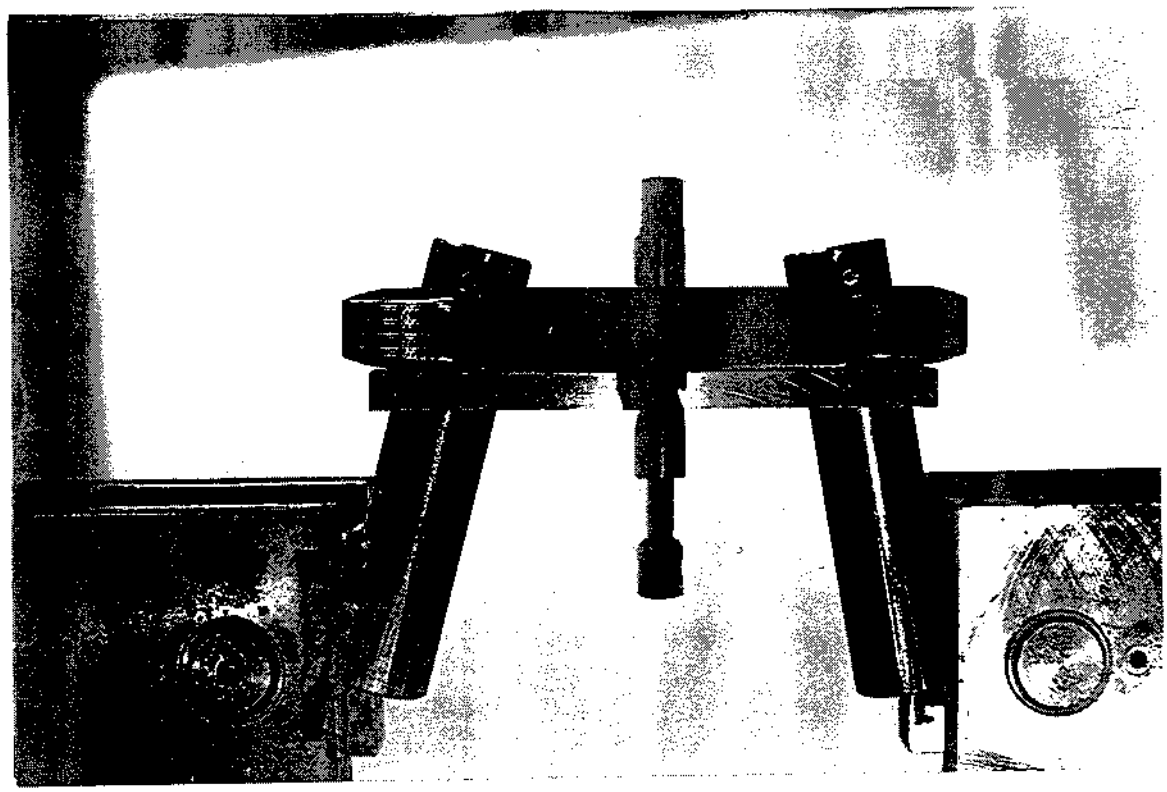


FIGURE 2 SYMMETRY SECTION AFTER TEST



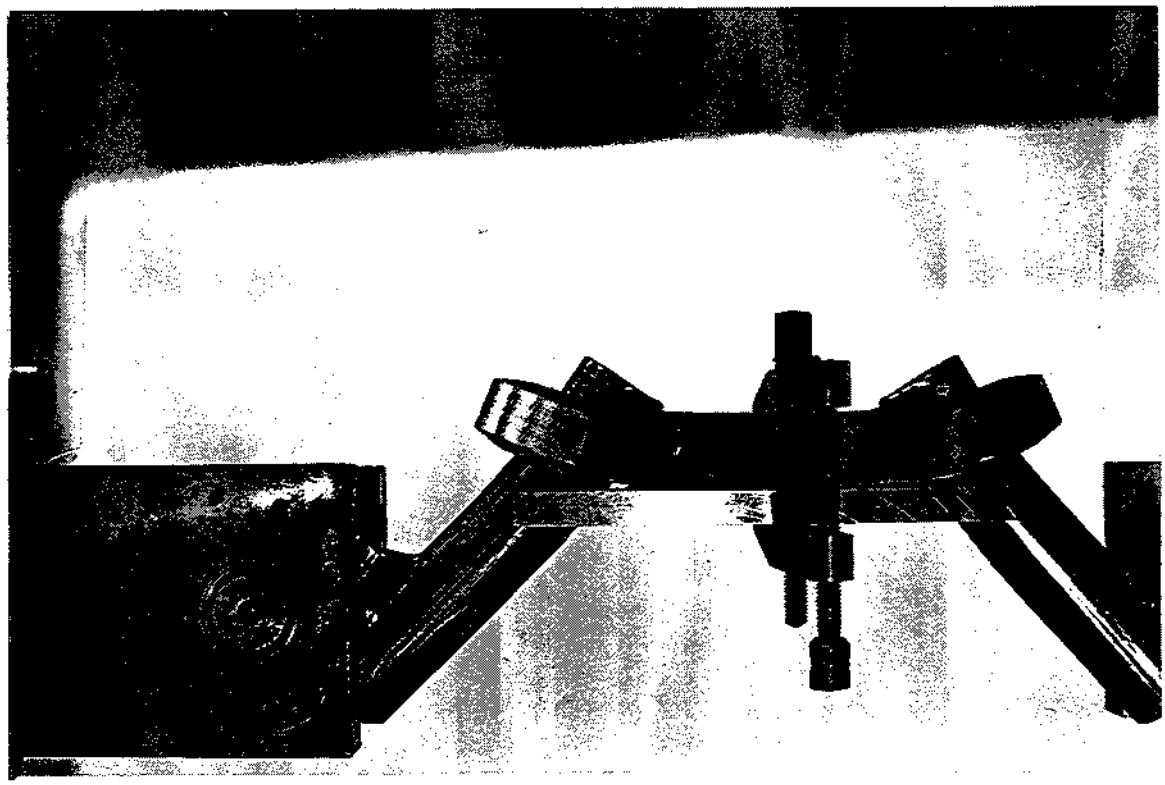
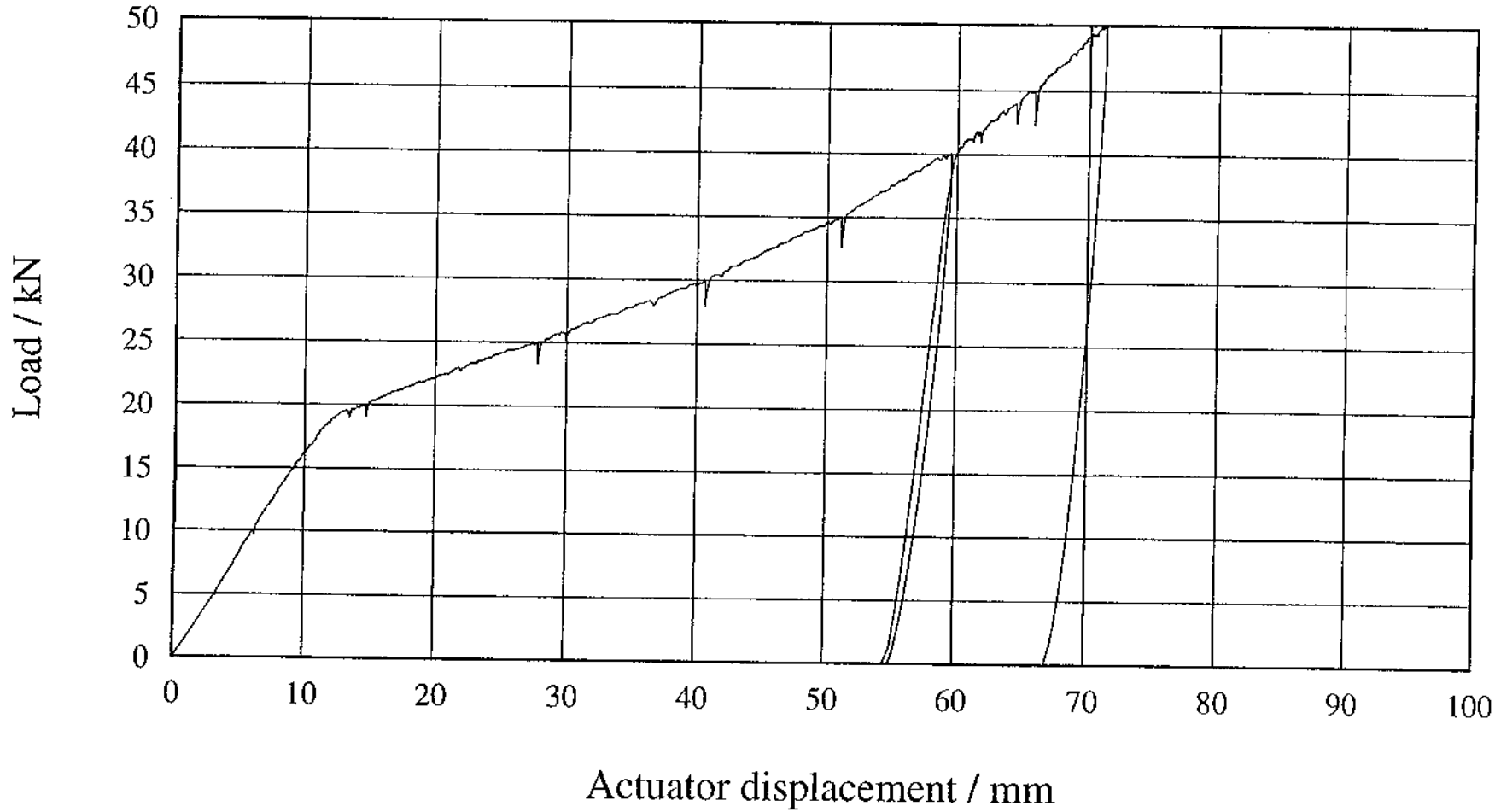


FIGURE 3 TEST SET UP AT 0.1 kN AND 50 kN

FIGURE 4



96-03-20

SUPPLEMENT No. 520

MS ESTONIA Bow Visor. Inspection Report of PS-side Hydr. Lifting Cylinder.

MacGREGOR (FIN) Oy.

Piikkiö 1995.

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T.Mäki

February 1, 1995

MS ESTONIA BOW VISOR

INSPECTION REPORT OF PS-SIDE HYDR. LIFTING CYLINDER

Type of the cylinder:	CD9-38725-6 250
Main dimensions:	
Outer diameter of the cyl.tube:	355mm
Inner diameter of the cyl.tube:	280mm
Diameter of the piston rod:	180mm
Diameter of the cylinder eyes:	160mm
Stroke of the cylinder:	1800mm

On the cylinder tube was stamped: 21.3.1980 TP 350 bar

Before opening the cylinder it was pressure tested on both sides and it was noted that there was no leakage on lifting side, but the oil went thorough the piston seals from piston rod side to lifting side. The piston rod was after this pressed completely out to inspect the piston rod condition and it was noticed that there was heavy damages on at the distance when the piston rod is about 400mm open.

The damages were on side SB-side of the piston rod. it was also noticed damages on piston cover's fixing screws. The ends of these hexagon screws were like hammered.

When the am. cylinder was opened the only damage inside was that the support ring and pressure seal which keep the pressure on the piston rod side was damaged which is most probably caused by very high pressure on piston rod side.

By the a.m. report we can see that the lifting cylinder has been opened at least about 400mm and there has been very high pressure on the piston rod side.

Kind regards,

MacGREGOR (FIN) OY
Marine Services
Tarmo Mäki

encl. photos

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