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January 20, 2011

U.S. Nuclear Regulatory Commission  
Document Control Desk

Washington, D.C. 20555-0001

Attention: Document Control Desk, via fax 301-816-5151

Subject: INTERIM REPORT  
Flowserve, Limit switch on Limitorque Actuators, Type SMB-00 and Type SMB-2-06

Gentlemen,

On January 14, 2011 Velan received from Flowserve the Final Report for Velan CAR 25500-73903 / Part 21 Evaluation of Geared Limit Switch (NRC Event # 46403).

Following our review of aforementioned document it was determined that in general it answers all our concerns; additional clarification was requested from Flowserve on the issue of corrective actions taken in assembly as well as any other departments or processes. The verbal explanation provided by Mr. Jeff McConkey, Limitorque QA Manager, was deemed satisfactory and we therefore decided to accept the conclusions of the report.

As a temporary measure we have instituted additional verifications that will be performed after the functional test of actuated valves equipped with the subject actuators and geared switches:

- verification of electrical continuity (using an ohmmeter), and
- verification that the finger contact arms are touching the rotor body in the electrically open state.

Please see attached the final evaluation report from Flowserve concerning the limit switches in the subject.

For any additional information on this matter please contact me at 514-748-7748 x 1134 or at [victor.apostolescu@velan.com](mailto:victor.apostolescu@velan.com).

**Please provide an e-mail address where a color ADOBE copy of this document can be submitted.**

Sincerely yours,

Velan Inc.

A handwritten signature in black ink, appearing to read 'Victor Apostolescu', is written over a faint, illegible printed name.

Victor Apostolescu, Eng.  
Vice President Quality Assurance

cc: Flowserve – Jeff McConkey via e-mail  
Velan – T. Velan, I. Velan, G. Perez, Z. Palko (via e-mail)

**CERTIFIED TO ISO 9001 QUALITY STANDARDS**

IE19  
IE20



January 14, 2011

To: Velan Inc

Subject: Final Report for CAR 25500-73903 / Part 21 Evaluation of Geared Limit Switch (NRC Event # 46403)

**Background:**

Velan reported they had an actuator become unresponsive after several cycles of open and close. Reference Velan order 219446 (DR 25500). They also reported the same condition on Velan order 217869 (DR73903). Verifying the source of the problem they found several gear limit switch finger assemblies damaged or bent. They also reported that some of the finger assemblies were tight with very little spring action. The following photos were attached to the CAR as evidence of these conditions.

- 2525 and 2526 showed a contact bent at the base near the setting screw
- 2527 showed a very tight finger assembly with minimal spring action
- 2641 and 2642 showed a finger assembly farthest from the base with minimal if any contact with the rotor button.
- 2528 showed a finger assembly with normal spring action.

Velan returned all above geared limit switches in question to Flowserve for evaluation

**Evaluation / Root Cause:**

Flowserve has completed a thorough evaluation of the SMB geared limit switch issue that was reported by Velan in CAR 25500-73903.

The bent finger condition that was noticed in photos 2525 and 2526 was evaluated and found that the finger was so severely bent that it would not make contact with the rotor button in the closed state. It is Flowserve's opinion that this damage could have been caused by a flat bladed screw driver catching on the rivet head during the switch setting process. While turning the intermittent gear shaft it is possible for the rotating blade of a flat bladed screw driver to contact the spring stud on the contact arm. This creates a bending moment resulting in the contact arm bending at the point where the spring stud passes through the contact arm. Once discovered, this failure mechanism was repeated in multiple trial tests. Subsequent 3-D modeling of the switch assembly reinforced this finding by identifying the contact area of a screwdriver with the spring stud. The photos below show the bent rivet from the above finger assembly and scarring on the head of the rivet.

The tight finger condition that was shown in photo 2527 was found to be caused by the clearance hole in the finger for the rivet to be on the low side of the print tolerance and some of the samples measured showed the hole diameter slightly smaller than tolerance. It was found through the engineering evaluation and 3-D modeling that this tight condition could possibly occur even if the hole diameter was to specification and at the minimal print tolerance. We tested multiple finger assemblies with completely tight to minimal spring action for 3,300 cycles and found no loss of continuity or bending of the contact fingers. Based upon this testing, it was

determined that producing a bent finger contact cannot occur during normal cycling operation of the switch even if the finger assembly is tight with no spring action.

The switch that had the condition depicted in photos 2641 and 2642 was tested as received and passed over 2,000 cycles with no loss of continuity. This switch finger was found to have very minimal contact with the button in the closed position as a result of the "L" bracket of the finger assembly being bent. This condition allowed for minute contact with the button but the finger assembly would stay stationary when the switch went to the closed position. The finger assembly was not tight and had full spring deflection. Unfortunately we did not notice this condition upon the initial testing which may have been the cause for the intermittent loss of continuity at Velan. This finger assembly was subsequently adjusted properly so the finger was touching the rotor body in the electrically open state and the switch was tested an additional 3,300 cycles with no loss of continuity.

The review of purchase orders and material certs of the switch components from 2007 to date showed no changes had been made to the materials or suppliers. The only deviation in the components found was the spring stud hole diameter on some of the fingers had fallen just below the minimum tolerance which may be a contributor to the tight condition. The switch assembly procedures and processes were reviewed and no changes were identified.

#### **Corrective Actions:**

Based upon this evaluation the following corrective actions have been implemented. The individual switch components have been reviewed and all critical inspection dimensions have been identified. The relevant in-process inspection plan has been reviewed and is being modified to include a visual inspection step to confirm that the finger contact arm is touching the rotor body in the electrically open state. This additional inspection will be documented on existing inspection form L-193.

#### **Conclusions:**

After cycle testing nine (9) switches from Flowserve stock, and seven (7) returned switches from Velan,; it was determined that producing a bend in the contact finger cannot occur during normal cyclic operation of the rotor. A bend in the finger assembly (finger and spring stud) with the use of a flat blade screw driver was duplicated several times. This can happen when turning the intermittent gear shaft during the GLS setting procedure. It was recreated in the 3-D solid models as noted above. This occurs only on the finger assemblies designated as 4L and 8R due to the lever action that can be produced as shown in the models. It is highly likely that this is the cause of the bent finger assemblies reported in the CAR. Evidence of the bent spring stud and scuff marks on the head of the stud are in support of this argument.

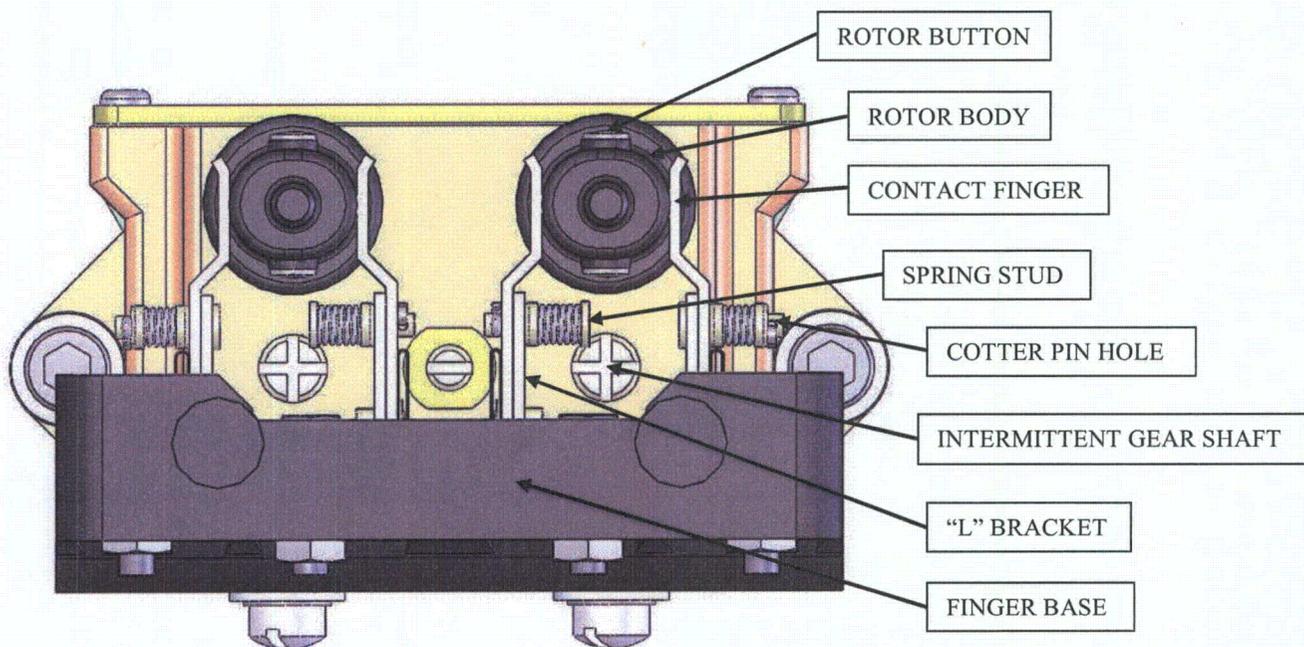
It is potentially possible a bend could result from a flat blade screw driver being wedged between the finger assembly and the contact button; however, it is highly unlikely.

The most significant event occurred during testing of the Velan switch from actuator serial # L852269. This switch, as with all of the returned Velan switches, was tested first in the as received condition. The loose finger base was tightened. No adjustments were made to any of the finger assemblies. Notes were taken to document which finger assemblies were "very tight" and which were not. This switch had several "very tight" finger assemblies. Visual inspection did not reveal any obvious bent finger assemblies. All contacts had initial continuity; however, with contacts in the open electrical state, finger contact with the rotor body was not verified. During the testing at 1,057 cycles continuity was lost on contact 4. The switch was allowed to complete the 2,000 cycle test. No additional contacts lost continuity. Visual inspection of contact 4 revealed that finger assembly 4L was no longer touching the rotor button. 4L was not a "very tight" finger assembly. After removal and closer inspection of the finger base from the gear frame it could be seen that there was a slight

bend in finger assembly 4L. The finger assembly was then removed from the finger base. The finger was disassembled and inspected. A bend in the spring stud was clearly evident. It is surmised that prior to initiating the cycle test the finger of contact 4 (switch state open) was not in contact with the rotor body, and in combination with the bent finger, bent spring stud and deformed cotter pin hole; produced dynamic mechanical reactions that eventually resulted in contact 4 losing electrical continuity. High powered macro photos were taken to look for any other damage. The photos revealed a scuff mark on the underside of the spring stud head. This scuff mark supports the argument that the edge of the flat blade screw driver can get caught under the spring stud head. When the screw driver is rotated, it pulls on the head and then pulls the finger and consequently both will bend. The force is great enough to damage the cotter pin hole in the spring stud. It was decided to reassemble the finger assembly, readjust the finger assembly and retest. The readjustment consisted of bending the "L" bracket enough so that the finger is touching the side of the rotor body. The switch was tested again. It was decided to extend the test for the 60 year life of 3,300 cycles. The switch functioned properly with no loss of continuity on any of the contacts. To further substantiate that a bent finger assembly can be readjusted and maintain proper continuity, a similar switch was built from Flowsolve stock and was tested for 3,300 cycles with no loss of continuity.

Visual inspections and macro photography of the finger assembly 4L of switch in photo 2652 revealed a very severe bend in the finger and spring stud, and severe deformation of the cotter pin hole. The scuffing on the top of the head indicates a strong screw driver rotation in the opposite direction. This again supports the argument of a flat blade screwdriver being used (see photos below).

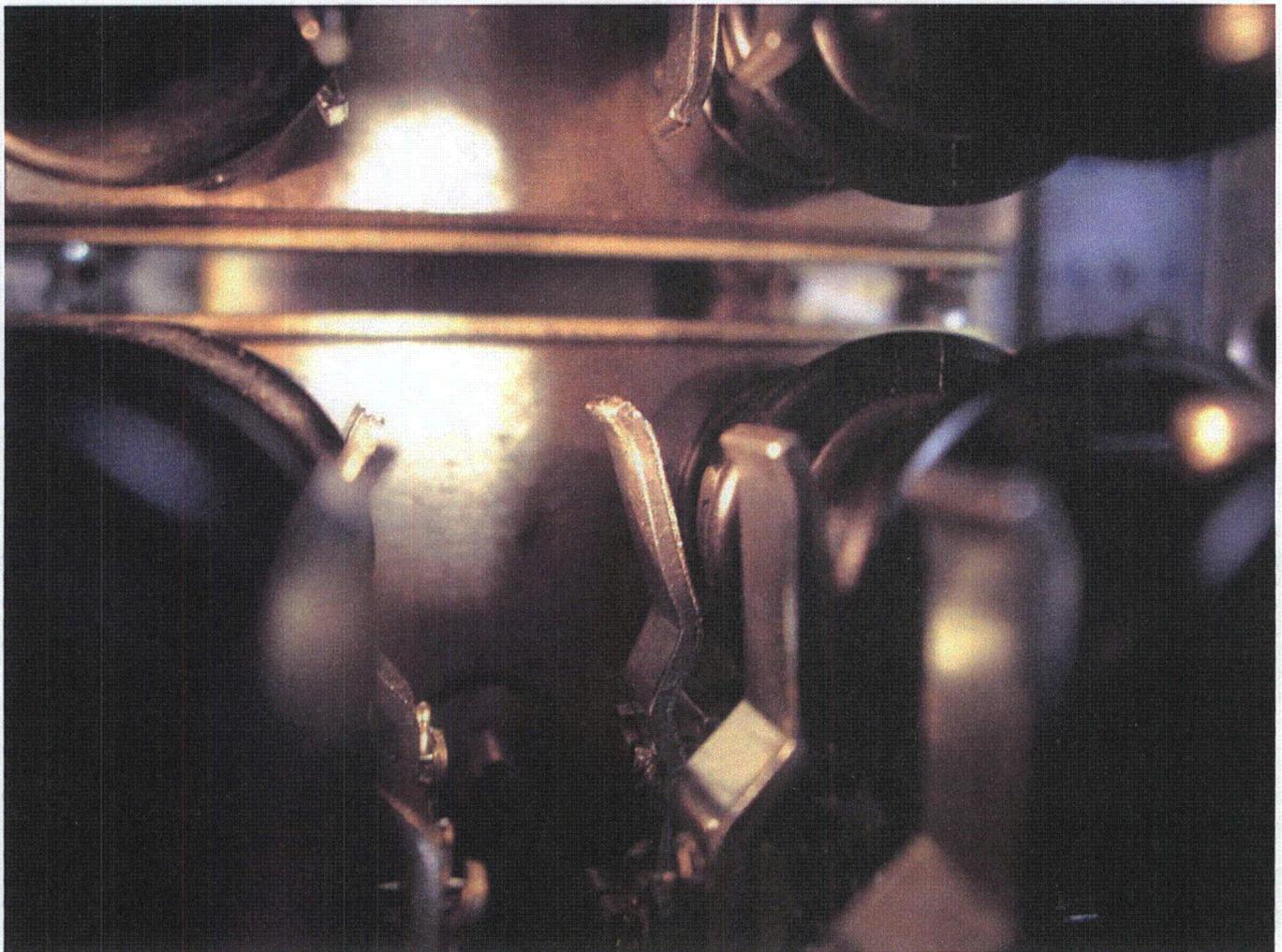
The model below should be utilized by Velan as a guideline for visual inspection to confirm proper switch operability. The assembly should be inspected to ensure that there is proper contact with the rotor body. Adjustments to the "L" bracket are permissible.



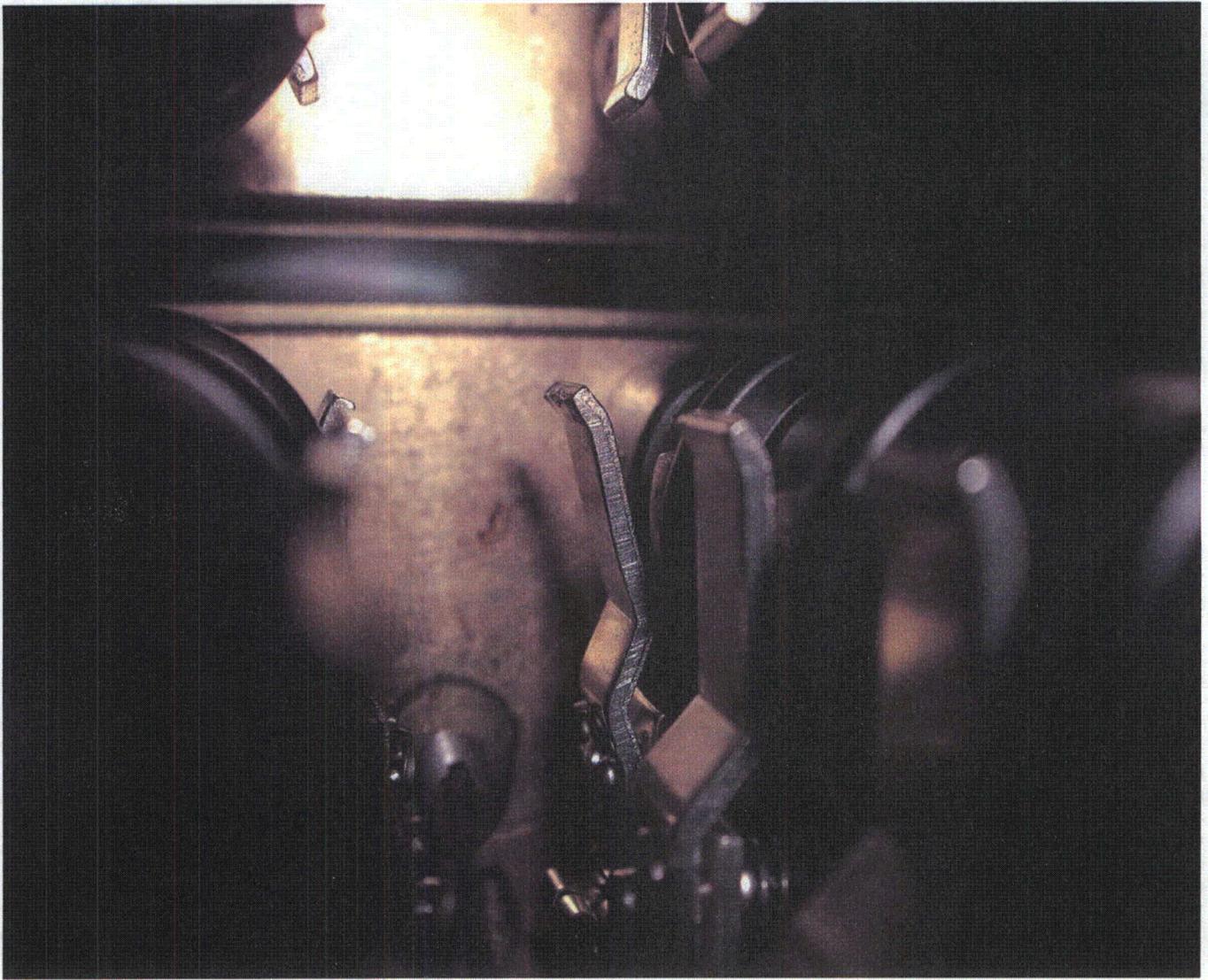
**Model shows finger assemblies touching rotor body in the electrically open position**

Based on the testing and evaluations of all Velan returned switches and switches from Flowserve stock, a design deficiency has not been identified. Properly set switches will perform their intended functions. Flowserve believes that this issue is not reportable to the nuclear industry under the guidelines of 10CFR50 Part 21 regulations. A maintenance update will be issued by Flowserve to guide the industry on any recommendations during their regularly scheduled maintenance outages.

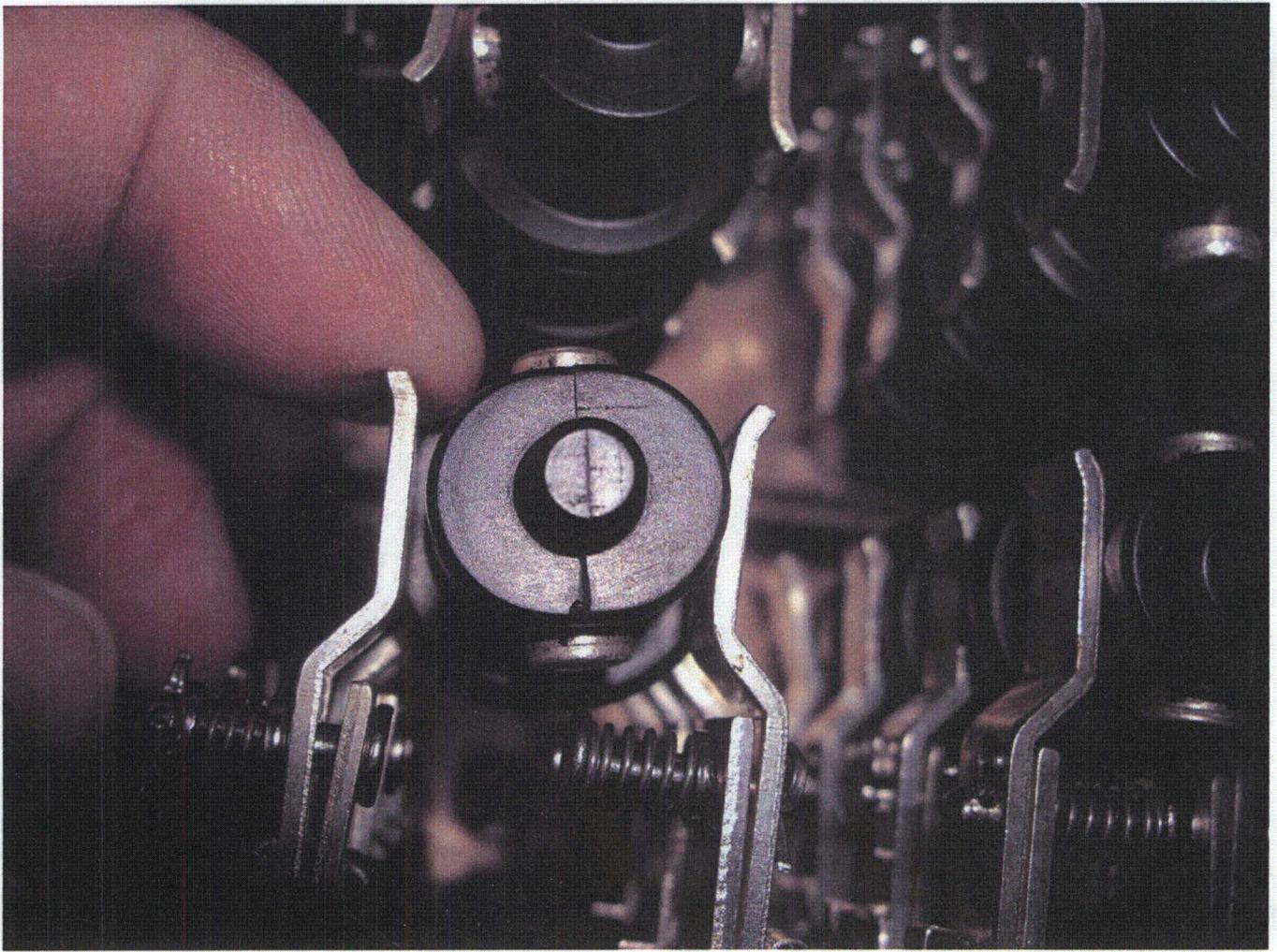
Jeff McConkey  
Manager Quality Assurance  
Flowserve - Limitorque



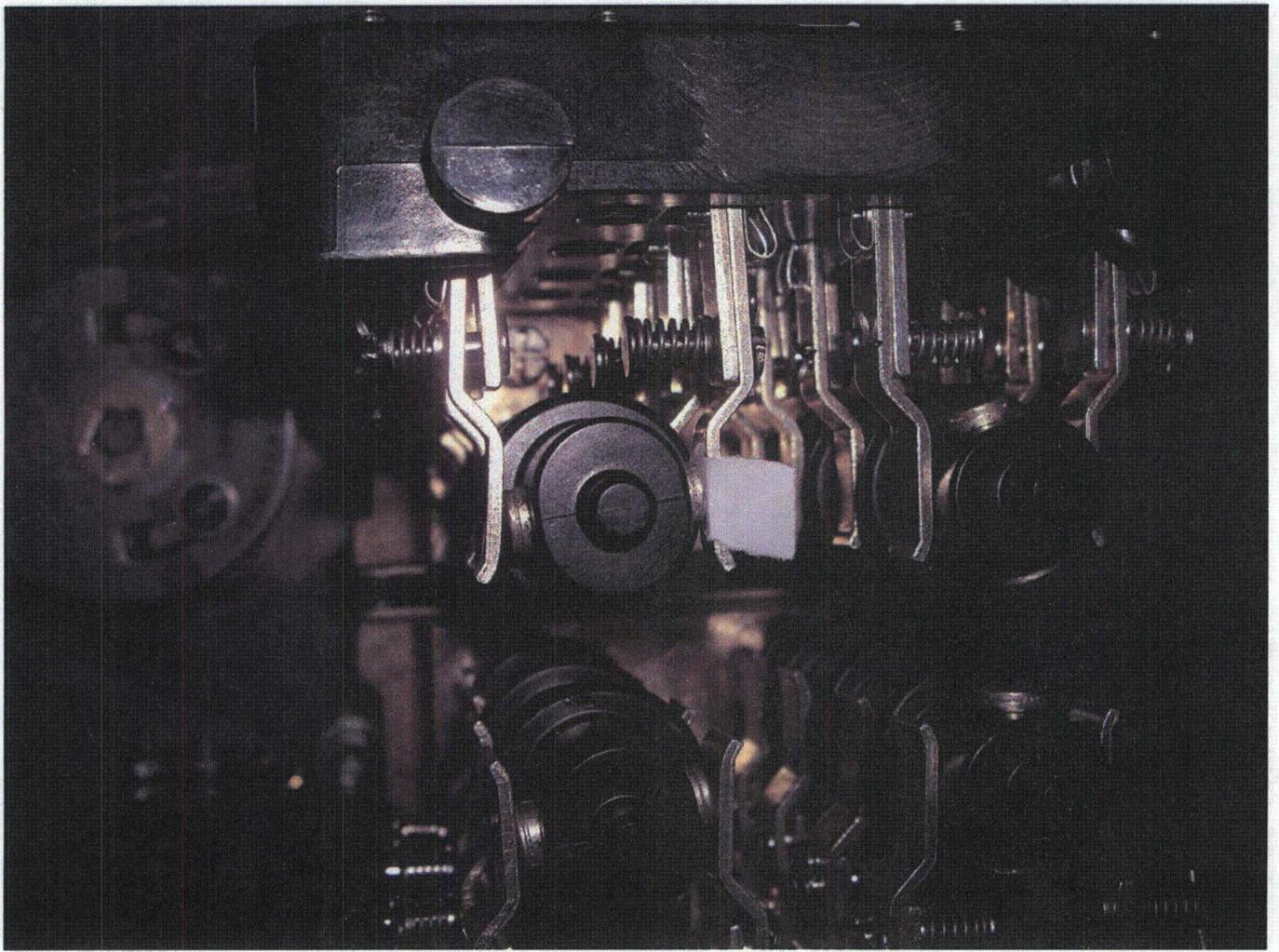
VELAN PHOTO 2525



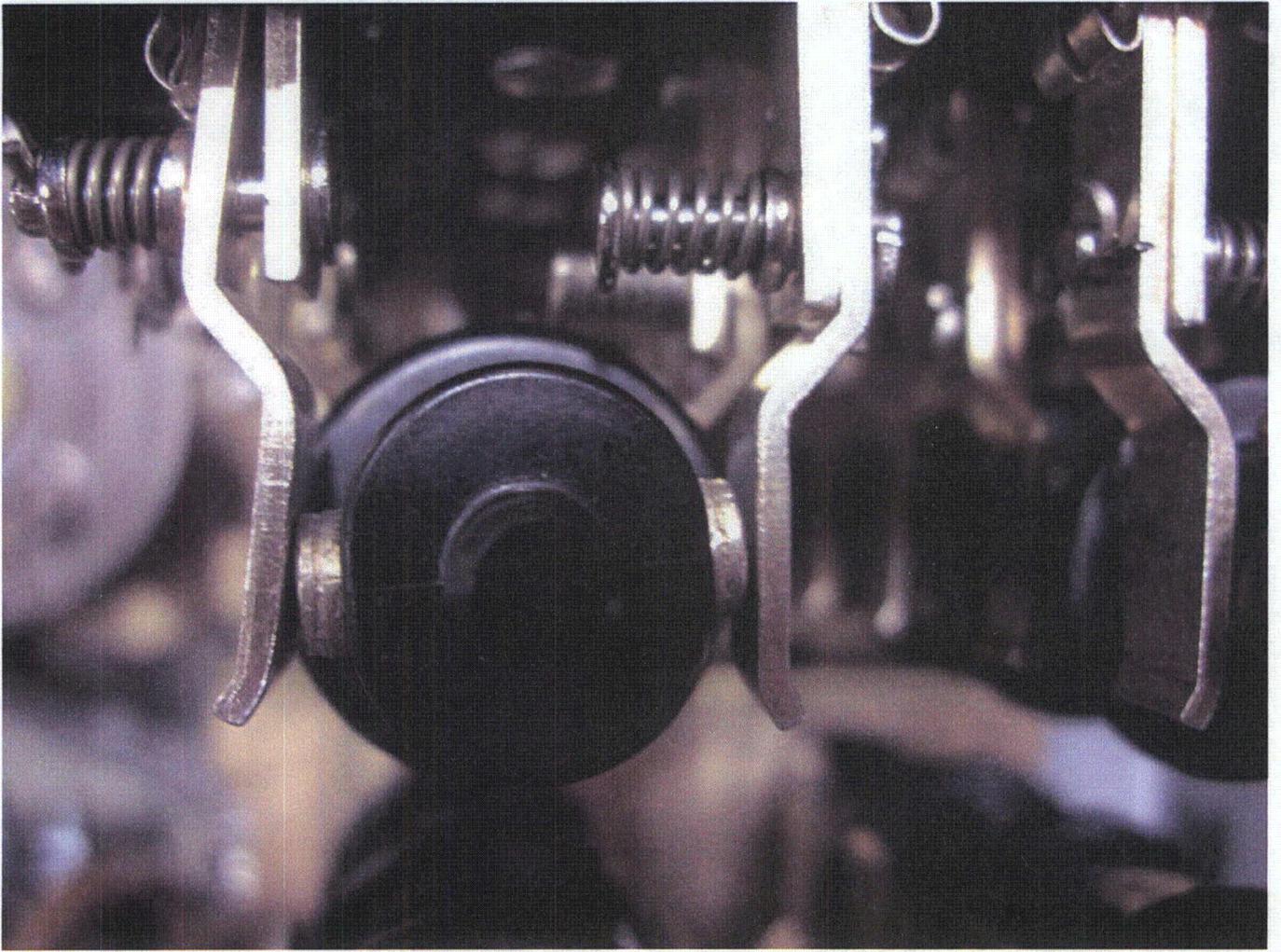
VELAN PHOTO 2526



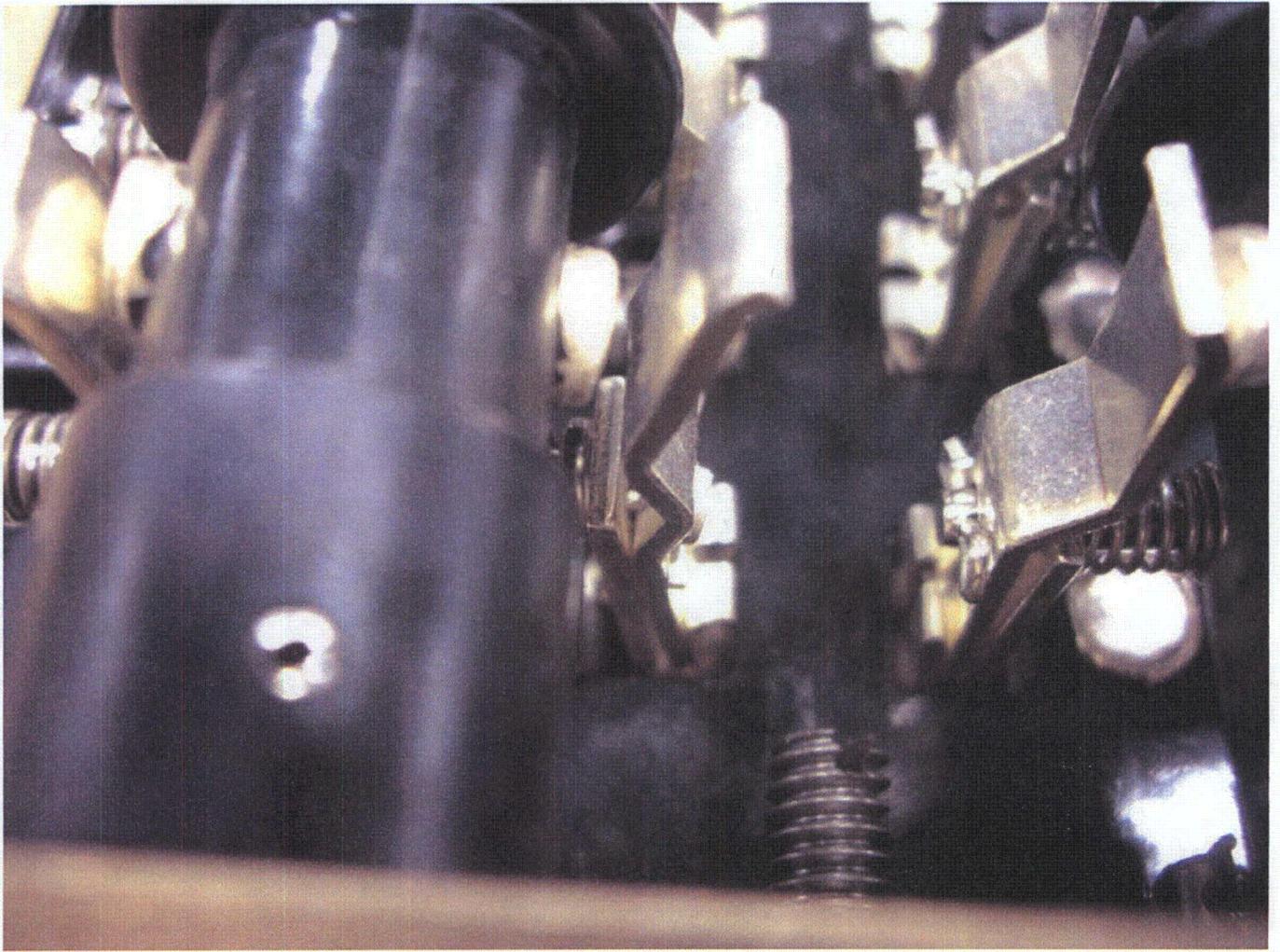
VELAN PHOTO 2527



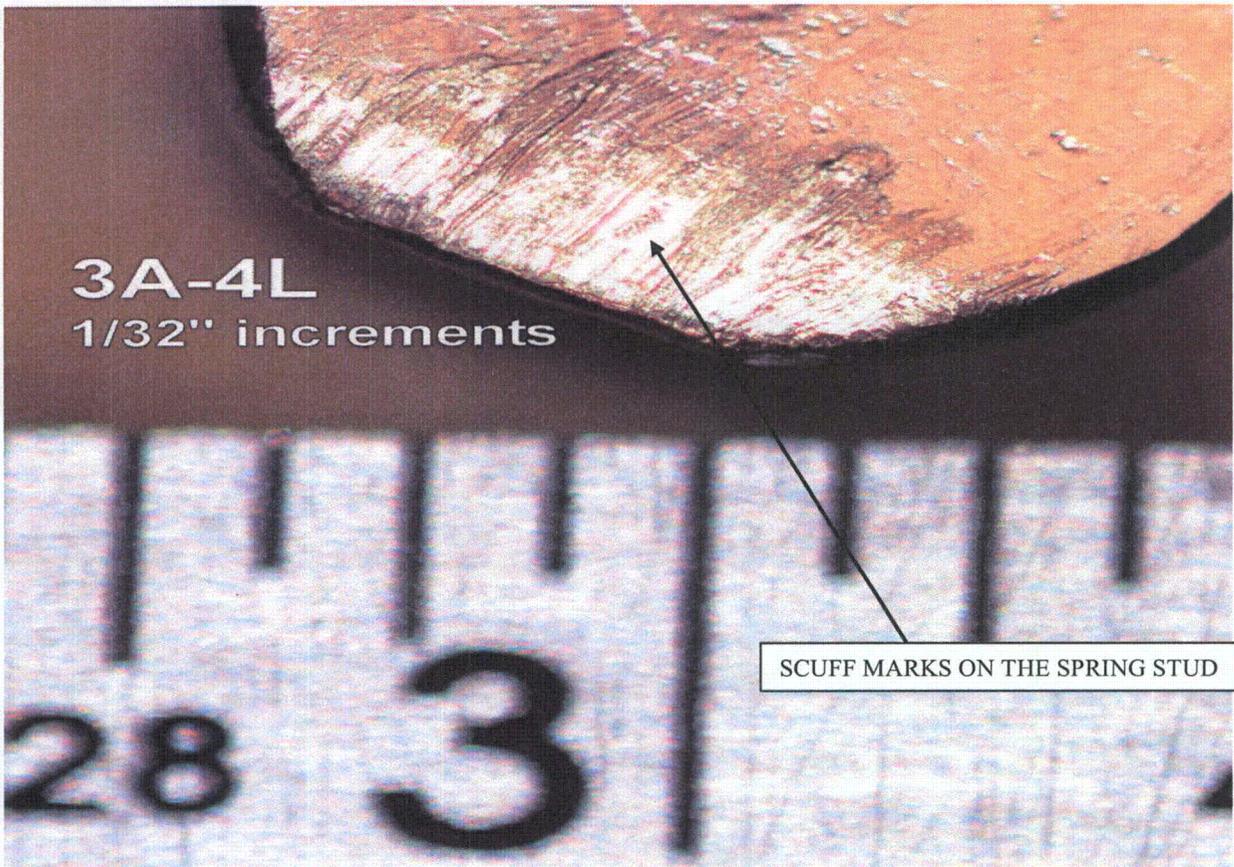
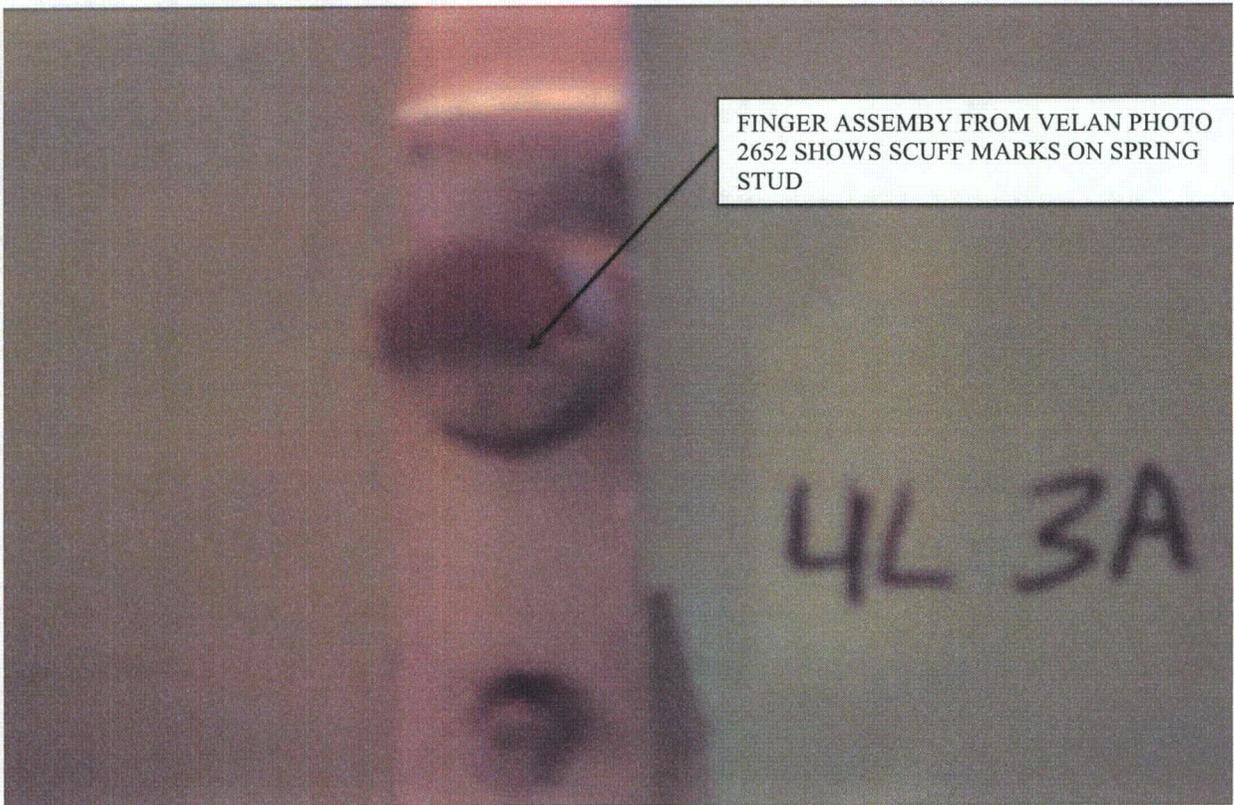
VELAN PHOTO 2641



VELAN PHOTO 2642



VELAN PHOTO 2652



3A-4L

1/32" increments

DAMAGE FROM A SCREW DRIVER BLADE



3A-4L

1/32" increments

BENT SPRING STUD WITH DAMAGE TO  
THE COTTER PIN HOLE

DAMAGE TO HEAD OF SPRING STUD



LAST PAGE OF REPORT