



10CFR21 Limitorque File No: 66
July 15, 2011

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Part 21 Evaluation of Geared Limit Switch - Nylon Bearing Retainer Cage

Purpose:

This report is a follow-up to an interim report filed by Flowserve Limitorque on June 3, 2011 which identified a potential deficiency in previous EQ test programs which qualified Limitorque SMB/SB/SBD-000 & 00 size actuators for inside and outside containment service. The interim report was issued because Limitorque was unable to complete the evaluation within the required time limit.

Issue:

As identified in the interim report (Attachment A), the SMB-000 & 00 geared limit switch assembly contains a ball bearing which includes a nylon ball retainer cage. A review of previous EQ testing identified that the retainer cage material may not have been thermally aged to an end of life condition prior to HELB/MSLB exposure. The concern was that degradation of the retainer cage could result in loss of functionality of the limit switch assembly in safety related applications.

Discussion:

This bearing is a subcomponent of the geared limit switch (GLS) assembly. The purpose of the bearing is the partial support of the input pinion shaft of the GLS cartridge. The input pinion shaft connects the GLS to the mechanical drive train of the actuator. This shaft is also supported by a bronze sleeve bushing in the cartridge. The purpose of the retainer cage in a radial ball bearing is to position the individual balls in the bearing assembly. As part of the evaluation, a sample bearing was installed in a GLS cartridge. Subsequently, the nylon ball retainer cage was intentionally removed from the bearing to simulate a worst case scenario of total degradation of the retainer cage. The removal of the ball retainer cage and the subsequent uncontrolled alignment of the individual balls inside the ball bearing race did not result in loss of GLS functionality. The input pinion shaft remained adequately supported by the sleeve bushing such that it is reasonable to conclude the GLS would perform its safety related function.

To further evaluate the adequacy of the nylon retainer cage equipped bearing for the accident environment, a thermal screening test of an SMB-00 geared limit switch assembly containing the subject bearing was performed. This test consisted of continuous exposure to a 340°F ambient temperature while cycle testing the limit switch. The test was halted after 270 hours (11.25 days) and 1600 operational cycles without failure. Post test inspection showed that the nylon retainer cage remained intact and functional which indicates that the degradation of the bearing discussed above is highly unlikely. No loss of functionality of the limit switch occurred during the test indicating acceptability of the bearing for the application. This screening test is documented in report # STLO-1125 retained on file and available for audit at Flowserve – Limitorque.

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Conclusion:

Based upon the evaluation described above and the existing EQ test data, Limitorque has determined that this issue is not reportable under 10CFR21 guidelines. The investigation has shown that in the unlikely event of degradation of the bearing retainer cage, safety-related functionality of the geared limit switch assembly will not be affected. Environmental qualification of the SMB/SB/SBD-000 & 00 actuators by Limitorque EQ reports B0058 and B0212 remains valid.

Jeff McConkey
Manager Quality Assurance

Kyle Ramsey
Chief Mechanical Engineer

ATTACHMENT A

June 3, 2011

Subject: Part 21 Evaluation Interim Report for Geared Limit Switch - Nylon Bearing Retainer Cage

This interim report provides information concerning an evaluation that is being performed by Flowserve – Limitorque regarding a possible deficiency in previous EQ test programs which qualified Limitorque SMB-000 & 00 actuators to IEEE-382 requirements for inside containment service. The relevant test program utilized a SMB-00 test specimen equipped with a 4-train geared limit switch. During the program, the limit switch assembly was thermally aged for a particular duration and temperature following IEEE-382 guidelines based upon an activation energy of 1.78 for the non-metallic Fibrite switch material. Recently, a statement in a 1989 NUGEQ Report on Limitorque EQ Clarifications pertaining to SMB-00 and SMB-000 gear limit switch bearings containing a ball bearing with a nylon retainer cage prompted a question from an operating plant about the activation energy of the nylon retainer cage material. An investigation to date has revealed that the non-metallic retainer cage material of the radial ball bearing may not have been properly considered when determining thermal aging requirements during EQ testing.

(i) Name and address of the individual informing the commission:

Lynn White, General Manager
Flowserve – Limitorque
P.O.Box 11318
Lynchburg, VA 24506-1318

(ii) Identification of the basic component supplied, which fails to comply or contains a defect.

The safety related component affected is the geared limit switch (GLS) assembly on actuator type / size Limitorque SMB/SB/SBD-000 and SMB/SB/SBD-00 only qualified for inside containment to Limitorque EQ report number B0058 and B0212. The sub-component of the GLS under evaluation is a radial ball bearing (manufacturer's part # 1604-DC and 7304-DC) manufactured by Nice / RBC Bearing Corp / SKF which has been used in the cartridge assembly. This bearing provides partial support to the input pinion shaft of the GLS. This bearing was manufactured with a nylon (polyamide 6/6) retainer cage.

(iii) The nature of the defect, or failure to comply, and the substantial safety hazard which could be created by such a condition.

The functionality of the cartridge bearing in the GLS assembly may not have been properly validated in an accident environment test with the non-metallic nylon material properly thermally aged to "end of life" condition. The currently available information regarding the activation energy of nylon, polyamide 6/6 material shows a wide range (average value 1.07, maximum value 1.77) Therefore, Limitorque acknowledges that the previous EQ test programs may have insufficiently thermally aged the bearing but is currently of the opinion that safety related functionality of the actuator will not be affected by the nylon cage bearing. Information in support of this opinion is as follows:

- a) The bearing in question was included in a 1985 EQ program which included thermal aging (100 hours at 238°F), radiation aging, mechanical aging, vibration and seismic aging, and accident

environment exposure. The post accident exposure inspection of the GLS did not indicate any issues with the GLS cartridge bearing. The post accident exposure baseline test showed normal GLS operation.

- b) In 1994, Limatorque performed an engineering evaluation of the thermal capability of the bearing retainer cage material which indicated a design life greater than 40 years.
- c) In an effort to further substantiate the previous analysis, in 2011 Limatorque has performed several screening tests exposing sample bearings to elevated dry heat temperatures simulating the maximum sustained temperature from the thermal profile of the HELB test without evidence of degradation of the nylon retainer cage in the bearing and no loss of GLS functionality related to the cartridge bearing. These tests involved cycling a GLS test specimen repeatedly while exposed to a continuous 340°F environment for a period of 150 hours.

Limatorque is continuing the evaluation of this issue in an effort to finalize this position.

(iv) The date in which the information of such a potential defect or failure to comply was obtained.
The initiation of the Part 21 evaluation was September 28, 2010.

(v) The corrective action, which has been, is being, or will be taken in order to preclude repetition of a similar defect. Date in which evaluation and action will be completed by.

At this point of the evaluation, Limatorque does not feel that the safety related function of the subject actuators will be affected by the existence of the nylon bearing retainer cage in the GLS assembly. Limatorque will continue the evaluation of this issue and will submit a status update on or before July 15, 2011

(vi) Any additional information relating to the defect in a basic component to provide useful information to the NRC or Licensee.

Limatorque provides the following information to help identify the actuators containing the bearing in question.

- a) This bearing is used on the 2-train and 4-train geared limit switch cartridge assembly of the SMB/SB/SBD-00 and the 4-train GLS cartridge of the SMB/SB/SBD-000 only.
- b) The GLS assembly used in SMB/SB/SBD-0, 1, 2, 3, 4 & 5 actuators use a slightly different cartridge construction that does not contain this bearing.

To date, the use of the nylon cage bearing in the GLS assembly has shown no negative affects on operability of the switch. This statement is supported by the following:

- c) SMB-000 & 00 geared limit switch assemblies has been operating successfully throughout the installed base for decades with no known reported problems related to the cartridge bearing.
- d) The bearing manufacturer's recommended operating temperature for the bearing is 248°F (120°C) continuous with intermittent operation as high as 338°F (170°C).
- e) The application of the bearing in the Limatorque actuator is intermittent duty and lightly loaded as compared to the rating of the bearing. The purpose of the nylon cage in the bearing is for ball retention only and has no direct affect on the rating of the bearing.

(vii) Name of technical contact at Flowserve
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Jeff McConkey – Quality Assurance Manager



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FROM: Kyle Ramsey

DATE: 7/15/2011

SUBJECT: Part 21 Evaluation of Geared Limit Switch – Nylon Bearing Retainer Cage

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