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Advanced LIGO Quadruple Pendulum Suspension Failure Modes and Subsequent Repair Approaches

Janeen H. Romie, Calum I. Torrie, Michael Perreur-Lloyd *

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of the LIGO Project.

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW17-161
175 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

http://www.ligo.caltech.edu/

* Institute for Gravitational Research, Dept. of Physics and Astronomy, University of Glasgow, Glasgow, G12 8QQ, U.K.

INTRODUCTION

This document details some problems that may occur with the quadruple suspensions after the suspensions have been installed in the chambers and the chamber has been closed. Following the list of possible failure modes is a list of subsequent repair approaches. This is a working document and as such, will evolve with the design. It will be updated periodically to capture any changes to the design that will affect the possible failure modes and repair methods.

FAILURE MODES

1) A fiber breaks, and the test mass sits on it's earthquake stops
2) An ear breaks off of a mass, and the optic sits on it's earthquake stops
3) The core optic hits the reaction mass/electrostatic drive coating and damages the coating.
4) A glued-on magnet comes off of the penultimate mass. It falls to the floor of the chamber without bothering anything else
5) A glued-on magnet comes off of the penultimate mass. It attaches to something (earthquake stop assembly) making the stop assembly unable to move.
6) A glued and bolted-on magnet comes off of the UIM, and falls to the floor of the chamber without bothering anything.
7) A glued and bolted-on magnet comes off of the UIM, and attaches to another magnet on the way down.
8) A glued and bolted-on magnet comes off of the top mass, not hitting or obstructing anything.
9) A glued and bolted-on magnet comes off of the top mass, and it attaches to something on the way down that makes performance diminish.
10) A wire breaks between a penultimate mass and an UIM blade.
11) A wire breaks between an UIM blade and a top mass blade
12) A wire breaks between a top mass blade and a top blade.
13) Any of the ECDs have a shorting problem.

REPAIR APPROACHES – coordinated with the numbered failure mode, above.

1) The suspension components are locked down with their earthquake stops above the stuck mass. The earthquake stop assembly – not the catcher – will have to be used to remove the bottom four masses (optic, penultimate mass, reaction mass and reaction penultimate mass) unless the stops themselves are one and the same for both the catcher and the stop

assembly, assuming the earthquake stop assembly and the catcher assembly are not in two separate sections.

2) Same as above.

3) Remove the earthquake stop assembly and then install the catcher assembly. Remove the bottom four masses and replace with suitable spare assembly.

4) Repair may not be required. Actuation is possible with only 3 actuators.

5) Go in the chamber and remove the magnet. Again, repair may not be required.

6) Same as 4.

7) Determine if the actuator with the double-decker magnets can be turned off. Make sure that the piggy-back magnet doesn't stop movement of the optic and reaction mass. If this is so, the piggy-back magnet will have to be manually removed.

8) This depends on which magnet it is. It probably won't be the magnets mounted on the top of the mass. It will probably be the side. Determine if the magnet is actually needed. If it is, lock down all suspended items and consider switching out the magnet in situ.

9) Same as 5

10) The same issues that came up in the 1) scenario applies here. The penultimate mass will be sitting on its stops. But, the catcher assembly needs to be installed to move the masses up into the upper part of the structure to allow for replacement of the wires.

11) Lock everything down and replace the clamp-wire-clamp assembly.

12) Same as 11.

13) Go in and mount the adjustment assembly onto the suspension ECD and move it to the proper orientation.