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George C. Marshall Space Flight Center
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TEST CONTROL DOCUMENT FOR ASSESSMENT OF FLEXIBLE LINES FOR FLOW INDUCED VIBRATION

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TEST CONTROL DOCUMENT FOR ASSESSMENT OF FLEXIBLE LINES FOR FLOW INDUCED VIBRATION

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NOTE: The portion of this specification affected by the changes is indicated by a vertical line in the outer margins of the page.

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LIST OF FIGURES

1.0 GENERAL

1.1 SCOPE. This specification outlines the methods and criteria to employ in flow testing bellows and flex hose assemblies.

1.2 PURPOSE. To establish a standard flow test procedure for detecting flow induced vibrations in a given bellows and flex hose assembly. The MSFC Drawing #20M02540 provides the analytical assessment for predicting cyclic stress, excitation frequencies, and resonant flow ranges.

2.0 TEST SPECIMENS

2.1 SELECTION. Specimens shall be randomly selected from a production run. Bellows and flex hose assemblies selected as representative of several assemblies for qualification purposes should represent equal or worst case conditions.

3.0 TEST REQUIREMENTS

3.1 GENERAL. All testing must be performed simulating actual operating life conditions (i.e., medium, temperature, internal and external pressure, etc.,) unless otherwise approved by MSFC.

3.2 NON-VACUUM JACKETED BELLOWS. When testing non-vacuum jacketed bellows with both a cryogenic flow media and an external ambient environment, provisions must be made to avoid the dampening effect of liquid air, frost, or slush on the convolutes. A helium purge environment may be used if heat transfer problems will not occur; otherwise, a vacuum environment (10^{-5} to 10^{-6} torr) must be used.

3.3 FLOW MEDIA. The bellows and flex hose design fluid media shall be used for flow testing and conform to all requirements for its intended operating condition unless otherwise approved by MSFC. If a substitute media is to be used, an additional analysis must be performed to verify the bellows or flex hose design integrity.

3.4 FACILITIES. The flow facilities shall be capable of flowing the service media under the bellows or flex hose actual operating conditions for the duration of four (4) times the operational life and be capable of flowing +/- 10 percent of the expected flow range.

3.5 OPERATIONAL LIFE. Operational life shall be defined as the time accrued when the number of missions is multiplied by the mission system operation time plus any ground checkout operations.

4.0 TEST SET-UP

4.1 GENERAL. The flow test set-up shall include the actual operating configuration assemblies and supports. The bellows and flex hose elements of the line assembly shall be deflected for worst case static loading. Installation of flow affecting hardware; such as orifices, transitions, valves, or bends, within ten (10) diameters upstream of the bellows is required.

4.2 INSTRUMENTATION. Each bellows and flex hose assembly shall be instrumented to measure cyclic stress levels and excitation frequencies without impairing freedom of movement or the integrity of the bellows assembly. Flowrate through the bellows and flex hose assembly shall also be accurately measured. Instrumentation shall conform to the state-of-the-art hardware, where practical and feasible. Due to the variety of methods that can be used to gather strain gage and accelerometer data, it will be left to the discretion of the testing organization, with MSFC approval, as to the method employed. The method chosen must adhere to the local codes and abide by current approved practices.

4.2.1 STRAIN GAGE ATTACHMENT. If strain gages are used, they may be attached using an adhesive such as epoxy (Eastman 910 or equivalent). Surface preparation generally requires an agent and light sandblasting. Location of the gages shall be as follows:

Free Bellows: Locate gages on the second convolute crown from the upstream end and on the second convolute crown from the downstream end. Also, locate gages at half the length of the convoluted section. See figure 1 for strain gage locations.

Flex hose: A wire braid cut-out is required to install strain gage (figure 2). Locate near upstream end for liquid flow and near downstream end for gas flow.

5.0 TEST PROCEDURES

5.1 INSTALLATION. With strain gages installed, deflect the bellows assembly (i.e. axial deflection, lateral off-set, and angulation) to worst case static loading seen during actual operating conditions.

5.2 RESONANCE SEARCH. With the bellows or flex hose installed to simulate worst case loading possible during operating conditions, conduct a resonance search by slowly varying the flow rate from zero flow to maximum operating flow plus 10%. Caution shall be exercised to vary the flow at a rate which will not allow resonance to go undetected. Substantiate the search by a downsweep through the same range of flows. Record frequencies, strain levels, and corresponding flow rates. The data from this search is then studied to determine the flow rate at which to perform the resonant dwell testing. If a flow resonance is not detected, continue the flow scan until four (4) times the operational life requirements are met, or a total scan time of 3 hours has been obtained.

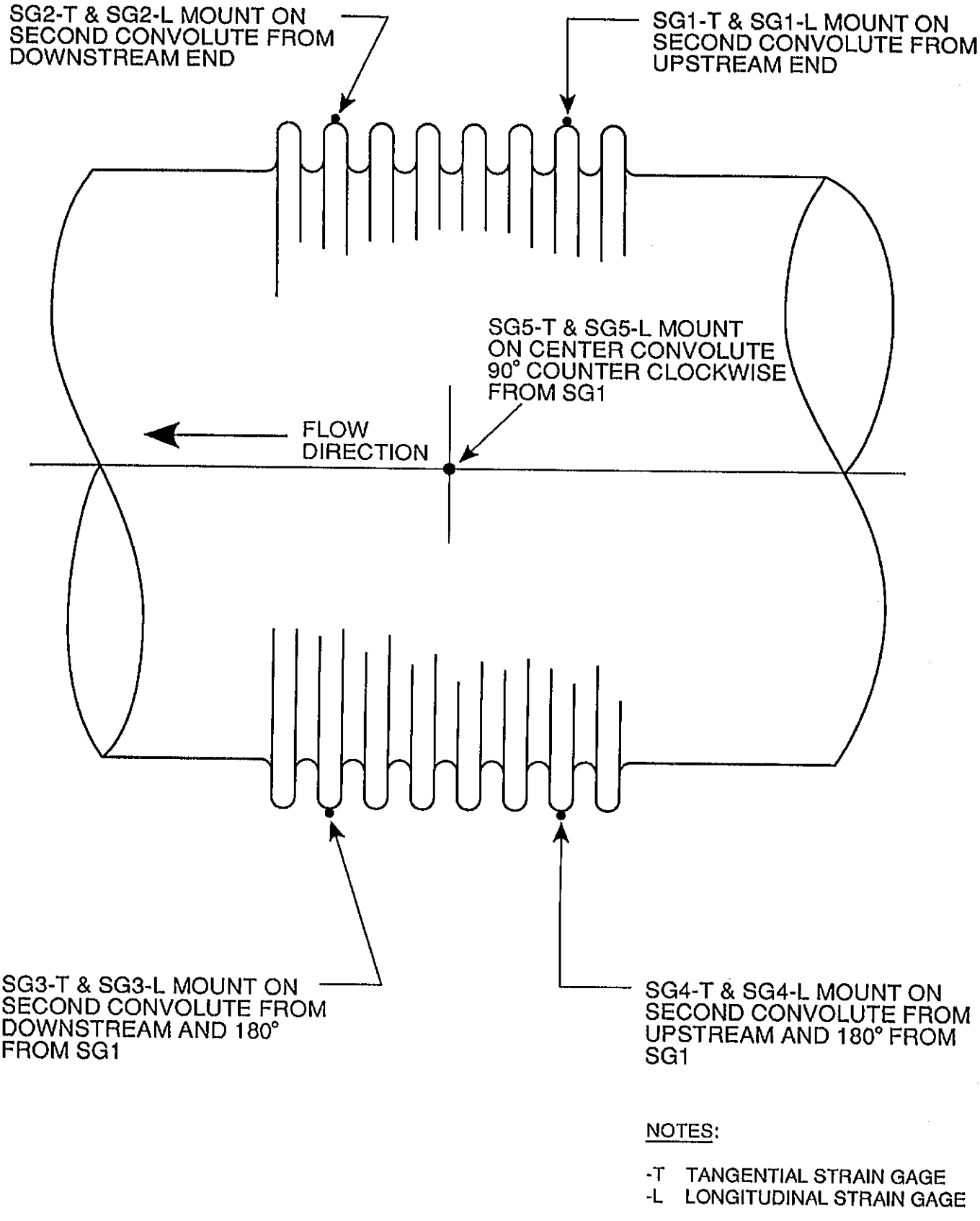
5.3 RESONANCE DWELL. This test will consist of dwelling at the most severe resonant conditions until the number of cycles equivalent to four (4) times the operational life have been accumulated at each resonance.

5.4 FAILURE MONITORING. A means to accurately determine the time to failure during the flow testing is required.

6.0 REPORTS

6.1 CONTENTS. Data shall include, but not be limited to, the following:

a. Bellows/flex hose identification
b. Measurement of as-built dimensions and a comparison to as-designed dimensions
c. Measurement of actual spring rate
d. Static conditions - pressure/deflection strains
e. Dynamic conditions - resonance search data
   - test flow rates and pressures
   - time to failure or test duration
f. Operational life requirements
g. Sketch of test set-up or photograph
h. Instrumentation utilized
i. Temperature measurements



NOTES:

-T TANGENTIAL STRAIN GAGE
-L LONGITUDINAL STRAIN GAGE

FIGURE 1. STRAIN GAGE LOCATIONS FOR A FREE BELLOWS

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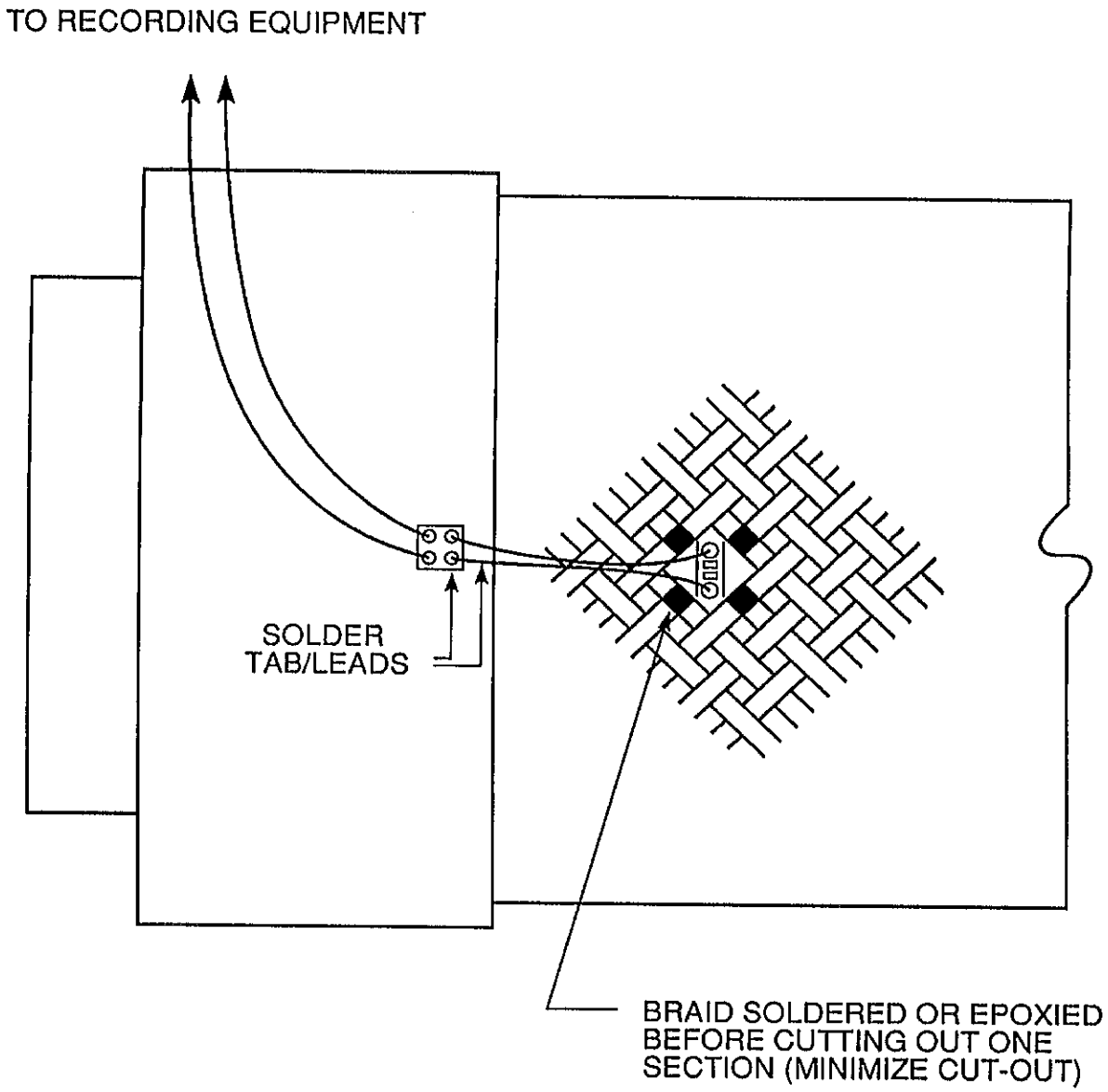

FIGURE 2. STRAIN GAGE INSTALLATION ON A FLEX HOSE

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