



SURFACE VEHICLE INFORMATION REPORT

J1927

JUN2014

Issued 1988-10
Stabilized 2014-06

Superseding J1927 MAR2009

Cumulative Damage Analysis for Hydraulic Hose Assemblies

RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE Hydraulic Hose and Hose Fittings Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be revised, reaffirmed, stabilized, or cancelled. SAE invites your written comments and suggestions.

Copyright © 2014 SAE International

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of SAE.

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
<http://www.sae.org>

SAE WEB ADDRESS:

Full document details: SAE J1927_201406

SAE values your input. To provide feedback
on this Technical Report, please visit
http://www.sae.org/technical/standards/J1927_201406

Documents

Document Sharing Hub

Foreword

WARNING—Hydraulic hose assemblies have a finite life and the exposure to surge pressures above the maximum working pressure will substantially reduce their service life. This analysis is intended to show the loss of hose working life due to elevated hydraulic pressures. Use of this SAE Information report is intended for those individuals that can produce a recorded history of pressure peaks and the frequency of the peaks. Under no circumstances should cumulative damage analysis be used unless recorded pressure history can be verified before implementing the design. Without proper documentation of the system pressure history, the application of any hose assembly above the rated working pressure is not recommended by hose manufacturers and will substantially decrease the working life of the hose. The user/installing company is accountable for the analysis and application of results.

1. **Scope**—This SAE Information Report is intended to provide the hydraulic system analyst with a procedure which will assist in the selection and use of high-pressure wire reinforced hydraulic hose assemblies. Many construction, agricultural, industrial, or commercial equipment systems utilize hydraulic hose assemblies that are subjected to irregular cyclic pressure variations (cannot be approximated by a constant amplitude pressure cycle). This document relates damage done by pressure cycles with the pressure-life performance curve for the hose assembly being evaluated, using a linear damage rule to predict fatigue life similar to that used for predicting metal fatigue life. More detailed information on the subject may be found in SAE Paper No. 880713. The accuracy of cumulative damage calculations is directly related to proper measurement of the service pressure history and pressure-life performance for the hose assembly being evaluated. Final selection of a hose assembly must also consider installation and maintenance as noted in SAE J1273.
- 1.1 **Background**—In the current SAE J517 for hydraulic hose, each style and size hose is assigned a maximum operating pressure rating to assure the user reasonable service life in a wide variety of applications. (See Appendix A for further explanation of nomenclature used in this document.) This rating is based on assessment of many factors, including repeated pressure cycling under controlled laboratory conditions at a pressure equal to or greater than the assigned maximum operating pressure. This standard test procedure, as detailed in SAE J343 minimizes variables so as to provide a baseline for performance capability. SAE J517 takes note that actual pressure cycling in a hydraulic system will seldom duplicate those test parameters precisely. It provides basic hose construction details; SAE J343 establishes standard test procedures—which may be utilized to develop data at pressures other than the established test value for any hose assembly. SAE J1273 provides a guide for selection, installation, and maintenance for hose and hose assemblies.

Many hydraulic systems will be subjected to variable amplitude pressure cycles, and in some of these the highest surge peaks will occur only a few times. Strict interpretation of SAE J517 indicates the use of hose assemblies with a maximum operating pressure equal to or greater than the highest peak—even if that peak should occur only once in the life of the system. If this were done, the hose would have more reinforcement, larger outside diameter, less flexibility, and higher cost than might be needed. It should not be necessary to use a hose that has over a million cycle capability at a pressure which is likely to occur only a few times in the application. What is needed, then, is a design verification procedure that assures adequate fatigue life for applications with variable amplitude pressure usage where the highest surge peaks are between 100 and 200% of rated pressure.

- 1.1.1 Cumulative damage of hydraulic hose is in many ways comparable to cumulative damage of metal components. The design verification of metal components is done in two ways depending on whether loading is of constant amplitude or variable amplitude:
 - a. Size the part cross section so the constant amplitude (maximum) load will not produce a stress at the highest stressed area in excess of the material “endurance limit stress.” This is a stress that will not cause failure in a million cycles of loading.
 - b. Do a cumulative damage analysis on the variable amplitude load or strain history to predict fatigue life as is normally done to evaluate prototype machines in the ground vehicle industry.
- 1.1.2 In a similar manner, hydraulic hose design verification should be done in two ways:
 - a. Select a hose assembly so the constant amplitude (maximum) pressure during service is less than the SAE J517 rated pressure.
 - b. Do a cumulative damage analysis with the variable amplitude pressure history to determine if the fatigue life will meet the design life of the product. The block diagram in Figure 1 illustrates how both the pressure history and the P-N curve information are the essential inputs for this procedure.

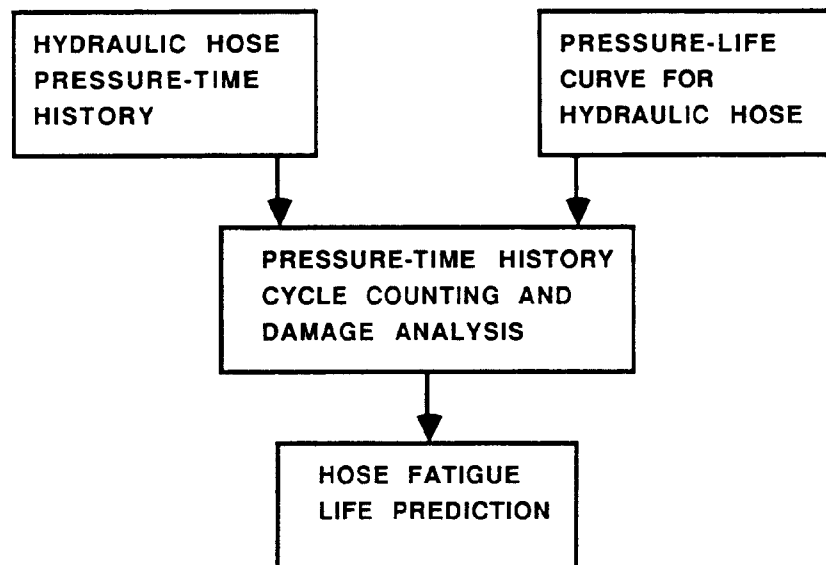


FIGURE 1—BLOCK DIAGRAM FOR HOSE FATIGUE ANALYSIS

For both metal parts and hydraulic hose assemblies, the first method is appropriate when the load (pressure) is known to be a large number of cyclic applications of nearly constant amplitude. However, if the load (pressure) involves infrequent cycling or includes only a few large peaks, then the first method may lead to designs that are heavy, bulky, inflexible, and more costly than need be. For variable amplitude loads or pressure applications, it is logical to do a cumulative damage analysis to judge the adequacy of the design.

Other factors, such as internal temperature, ambient temperature, and ozone exposure, for all intents and purposes, have not been considered in this cumulative damage analysis procedure. Long-term exposure to extreme limits or high levels of these elements could affect the overall hose assembly life.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J343—Tests and Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies

SAE J517—Hydraulic Hose

SAE J1273—Selection, Installation, and Maintenance of Hose and Hose Assemblies

SAE 880713—SAE Test Program on Cumulative Damage for Hydraulic Hose Assemblies

3. Use of P-N Curves in Design—A cumulative damage analysis is needed for a hydraulic system subjected to variable amplitude pressure cycles if system pressures in excess of rated pressure are to be in the design consideration. An approach for this analysis is to use the Reference P-N curve as defined in the previously mentioned reference paper and shown in Figure 2. Verification that the actual hose assemblies have a P-N curve in excess of the Reference P-N curve is essential. The equation for the Reference P-N curve in Figure 2 is:

$$P_a = P_b(N)^s \quad (\text{Eq. 1})$$

where:

P_a = Zero-to-Max amplitude of pressure cycle

N = Cycles to failure at pressure amplitude P_a

P_b = Burst pressure (one cycle life)

s = Slope of curve on log-log plot

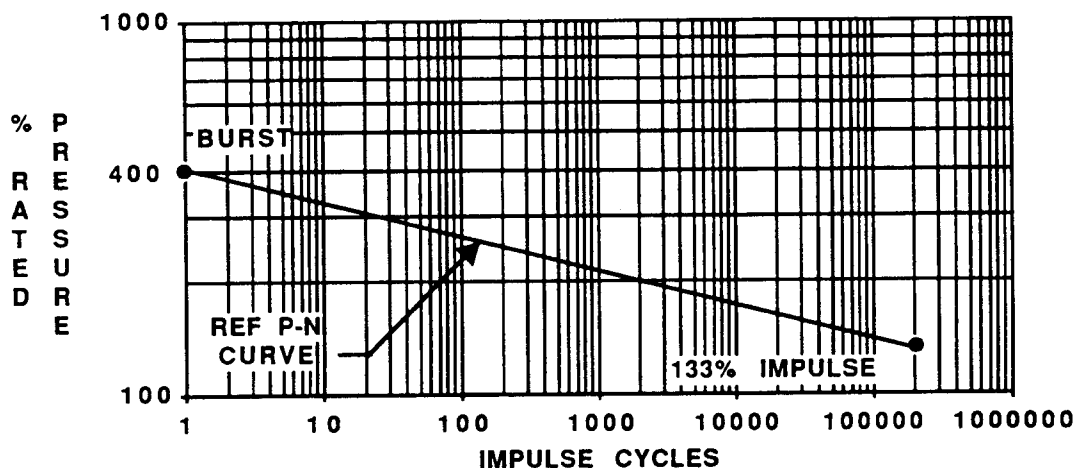


FIGURE 2—HYDRAULIC HOSE PRESSURE-LIFE PERFORMANCE CURVE (SECTION 3)

WARNING—This figure is here to show the concept of Equation 1. This should be used for conceptual purposes only. The user is responsible for the actual graph. The user's graph needs to be based on actual history of tested data.