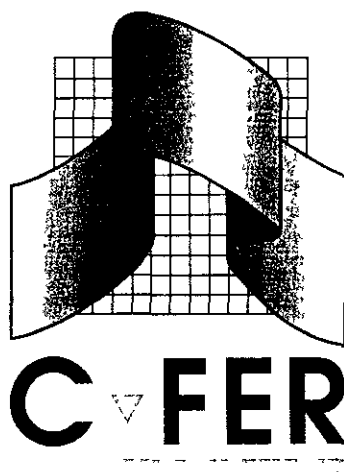






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Summary Report

**Full Scale
Performance Tests
of Environmentally
Acceptable Thread
Compounds**

**Prepared for:
API Item 1033a
Thread Compound Research
Technical Advisory Committee**

**Prepared by
D. M. Shute, P.Eng.**

**Reviewed by
M. W. Slack, P.Eng.**

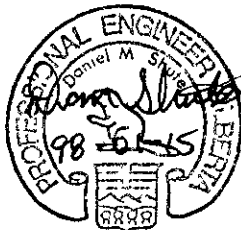
**December 1997
Project 94011 & 95006**

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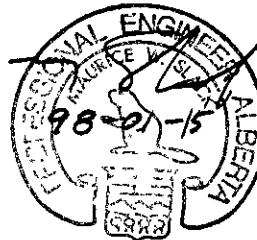
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This document describes the methodology and findings resulting from a test program developed by the American Petroleum Institute (API) Committee 5, Technical Advisory Committee as a continuation of API PRAC XX-51, Thread Compound Research (the "Program"). The program was performed by the Centre For Engineering Research Inc. ("C-FER") of Edmonton, Alberta, Canada and was structured to complement a companion Joint Industry Project (JIP) sponsored by Mobil Exploration and Producing Technical Center through the Petroleum Environmental Research Forum.

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LIST OF PARTICIPANTS

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1. INTRODUCTION

This report summarizes the results of a combined American Petroleum Institute (API)/Joint Industry Project (JIP) test program to investigate the performance capabilities of thread compounds for oil field casing and tubing that are being developed and marketed to meet current and anticipated environmental requirements (Environmentally Acceptable Thread Compounds or "EATC"s). This test program was developed by the API Committee 5, Technical Advisory Committee (TAC) on Thread Compound Research as a continuation of API PRAC XX-51^{*}. It was structured to complement a companion Joint Industry Project (JIP) sponsored by Mobil Exploration and Producing Technical Center (MEPTEC) through the Petroleum Environmental Research Forum (PERF). The API portion of the total test program was designed to provide benchmark/baseline sealing, friction and galling data using three generic 'reference' compounds. The reference compounds were formulated to represent:

1. A "nominal" API Bulletin 5A2, "Modified Thread Compound" formulation (A or API-Test);
2. A compound defining a poor sealing performance limit (C);
3. A compound defining a poor galling resistance limit (B).

The JIP portion of the total program allowed for testing of three commercial formulations (JIP 1, 2, and 3), selected by the JIP participants, under parametrically identical conditions. The thread compounds were evaluated by means of full-scale make/break and pressure testing, using three different connection types: 8-round tubing, 8-round casing, and buttress casing.

The API TAC and the JIP separately contracted the Centre For Engineering Research Inc. (C-FER), in December 1993, to conduct both portions of the test program. The funding for the API portion of the program was provided through the Production Waste Issues Group (PWIG) by the API Executive Committee on Environmental Conservation (ECEC). The funding for the JIP portion was provided by the JIP participants.

^{*} API Committee 5, Report on PRAC Project 88, 89, 91-51: "Investigation of Pipe Thread Compounds," Nov., 1992

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The terms of reference for this contract are experimental rather than analytical; therefore reporting is primarily restricted to presentation of the test apparatus, procedures and results. Complete data sets for each portion of the test program have been prepared and presented under separate cover to the API TAC and the JIP participants.

2. BACKGROUND

Virtually all areas of the petroleum industry have been affected over the last several years by the environmental regulatory pressures to change certain operating practices and procedures, as well as materials, that have been utilized for decades. One of the areas most notably affected is that of thread lubricants and sealants (compounds) that are required for the assembly of all oil field pipe connections. Thread compounds are critical in the prevention of connection damage during the make-up, running, and break-out of oil field tubulars. They must also provide an effective seal against high internal pressures at elevated temperatures and for extended periods of time. Historically, thread compounds have contained a substantial amount of finely divided, heavy metals such as lead or zinc that are blended into a lubricating petroleum base grease. The unique properties of heavy metals provide resistance to galling of ferrous metal surfaces at high contact bearing stresses and effectively seal potential leak paths against high internal pressures. Several heavy metals are currently named on Federal, State and Municipal environmental toxicity lists that require the reporting of, and restrict the use and disposal of, materials that contain these elements. Currently the lead content of thread compounds is the primary concern although the use of zinc and other metallics is becoming increasingly restricted.

The thread compound that has been used universally for over forty years on tubing and casing connections is the formulation defined in obsolete API BUL 5A2: "*Bulletin on Thread Compounds for Casing Tubing, and Line Pipe*", and is known to the industry as API Modified Thread Compound. This formulation contains 45% by weight heavy metals including 30% lead. The Industry became aware of the potential environmental problems of compounds containing heavy metals in the late 1970s. These problems included the disposal of compound residues in hydrostatic tester sumps, contamination of soil in storage and inspection facilities, disposal of compound containers, and contamination of mud pits in field operations. In 1984 the API Committee 5, Production Research Advisory Committee (PRAC), authorized a Technical Advisory Committee (TAC) to initiate a research project to develop standardized test procedures and set performance criteria for thread compounds for use on API casing and tubing connections. The goal of the project was to rewrite the formula-based BUL 5A2 as a performance-based API standard for the evaluation of thread compounds. The basis of the new standard was envisioned to be small-scale laboratory tests

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that would define the frictional properties, galling resistance, and sealing performance of a thread compound. A performance-based standard allows thread compound manufacturers to develop, and users to evaluate, environmentally acceptable thread compounds, on an ongoing basis, as regulations change and restrictions increase. Considerable work has been done in the course of the API thread compound research project to address these needs. The main obstacle to the completion of the project has been the lack of controlled full-scale test data to validate the proposed small-scale test procedures. This test program is intended to supply the controlled full-scale test results.

3. PROJECT OBJECTIVES AND SCOPE

The incentives for this project thus derived from the dual needs for thread compounds to meet environmental demands and performance requirements. In addition, the results of this project were intended to contribute toward the performance based standard for thread compounds^{*} replacing the obsolete prescriptive standards. This initiative is critical to ensure that the replacement of compounds believed to *reduce* environmental risk through lowered toxicity do not inadvertently *increase* risk through reduced service performance.

The scope for this project was therefore designed to provide certain comparisons of full scale compound sealing, friction and galling performance using API Modified Thread Compound as the 'benchmark' or reference compound. The API funded portion of the combined program is primarily directed toward providing this reference information by defining the service performance of API Modified under conditions parametrically identical to those used for testing proposed EATCs within the JIP. In addition, the work scope includes two "worst case" baseline compounds. These specially prepared compounds were included to provide an indication of the limiting performance boundaries for the sealing, friction and galling properties of EATCs. This project also includes the objective of evaluating the ability of the employed test procedure in differentiating discrete compound performance parameters.

^{*} API Recommended Practice 5A3 (RP 5A3): "Recommended Practice on Thread Compounds for Casing, Tubing, and Line Pipe"; First Edition, June 1996

4. TEST PROGRAM SUMMARY

The details of the test program defined by the API TAC and approved by the JIP are contained in the appendices of the full data reports. Tables 1 and 2 show the test matrix and parameter specifications for the API and JIP sections of the project. The 'task groups' identified in these Tables use detailed procedures defined as follows:

6.0. Full Scale Test

6.1. Full-Scale Tubing Connection Testing for Evaluating LP-C&T Thread Compounds (December 17, 1992);

6.1.1. Full-Scale 3 1/2 inch API EU Make-up/Break-out Test Procedure LP-C&T Thread Compound Evaluation Program (December 17, 1992);

6.1.2. Full-Scale 3 1/2 inch API EU Sealability Test Procedure LP-C&T Thread Compound Evaluation Program (December 17, 1992);

6.2. Full-Scale Casing Connection Testing for Evaluating LP-C&T Thread Compounds (December 17, 1992);

6.2.1. Full-Scale 9 5/8 inch Buttress and 8-Round Make-up/Break-out Test Procedure LP-C&T Thread Compound Evaluation Program (December 17, 1992); and

6.2.2. Full-Scale 9 5/8 inch Buttress Sealability Test Procedure LP-C&T Thread Compound Evaluation Program (December 17, 1992).

Reference compounds were formulated and supplied to C-FER by a designate of the Technical Advisory Committee (TAC). The API test compound was prepared as described in Table 3. Commercial compounds were selected by the JIP participants and supplied by the thread compound manufacturers. Tubular specimens were supplied by the JIP participants..

4.1. Specimen Description and Identification

Three distinct connection types were used in the test program as follows:

1. 3 1/2 inch EU 8-round tubing, L-80, 12.95 ppf
 - Make-Up/Break-Out & Sealing
2. 9 5/8 inch 8-round casing, LTC, L-80, 53.50 ppf
 - Make-Up/Break-Out

Test Program Summary

3. 9 5/8 inch buttress casing, BTC, L-80, 53.50 ppf
 - Make-Up/Break-Out & Sealing

One specimen set consists of two pins and one coupling. A connection set consists of three specimen sets of each connection type. Each connection set includes specimen sets of the following taper variables:

1. Fast Pin/Slow Box;
2. Nominal/Nominal;
3. Slow Pin/Fast Box.

Pins and couplings were gauged and matched to produce the specified combination of taper variables. Each commercial compound was tested on one connection set of each connection type.

Specimen identification is detailed within the data presentation appendices of the full data reports in the following format:

##LL##:

where:

- the first pair of numbers identifies pin specimen number;
- the first letter identifies the pin taper as fast (f), slow (s), or nominal (n);
- the second letter identifies the coupling taper;
- the second pair of numbers identifies the coupling specimen number.

4.2. Make/Break Tests

Make/break testing was intended to characterize the frictional and galling behavior of the test thread compounds on a range of connection sizes and threadforms. In general, the testing procedure followed the detailed make/break test procedure presented in Appendix I, of the full API data report; except for the definition of reference torque. Because the frictional properties of the test compounds, due to variances in composition and particle size distribution of the solids pack, were substantially different than API Modified; using the prescribed make-up procedure of a fixed reference torque plus turns resulted in significant variations in the initial hand tight stand-off. In some cases, this was more than one full turn. This resulted in excessive engagement, high final torques and associated galling. The procedure was therefore modified to identify a reference torque intended to coincide with an initial stand-off position equivalent to that obtained for Compound A (API - Test) as follows: