SCIENTIFIC AND TECHNOLOGICAL COOPERATION BETWEEN THE UNIVERSITY OF PETROLEUM & MINERALS AND AUSTRIA: RESEARCH ON THE CORROSION BEHAVIOR OF STEELS AND ALUMINUM ALLOYS IN SALINE WATER

Fahd H. Dakhil

Vice-Rector for Graduate Studies and Research, University of Petroleum & Minerals, Dhahran, Saudi Arabia

and

P. Koss

Austrian Research Center, Seibersdorf, Austria

The development of new technologies and the fail-safe design of technical structures to operate in a saline aqueous environment depend to a large extent on the availability of suitable engineering materials capable of withstanding such aggressive media. Extensive knowledge on the performance of engineering materials and judicious selection of candidate metals and alloys for specific practical applications are of utmost importance to the industrial and long-range economic development programs of Saudi Arabia. Moreover, expertise in recognizing the causes of corrosion failure is invaluable for devising preventive measures, thereby reducing the impact of corrosion, which is one of the most serious factors responsible for exorbitant economical losses in industrialized nations.

In view of the importance of active participation in a wide range of corrosion research work, an international cooperation program has been initiated by Rector Dr. Bakr A. Bakr between UPM in Dhahran on the one hand, and the Austrian Research Center Seibersdorf on the other. Several Austrian industrial centers and research organizations participate in this cooperation (Table 1). The subjects of this long-term research effort were initially defined jointly between Vice Rector Dr. A. A. Al-Gwaiz and the Austrian partners in November 1975.

0377-9211/81/030159-03$01.00

Essentially, three consecutive phases were planned [1]:

(i) Definition of the standardized corrosion test methods essential to support long-range Saudi Arabian industrial development projects followed by round robin tests to verify the performance of the test equipment available to each of the participants (Table 2).

(ii) Evaluation of alloys selected by the Austrian manufacturers by static corrosion test procedures using natural water (tests at UPM) and synthetic salt water simulating the naturally occurring water (tests by the Austrian participants) (Table 3).

(iii) Evaluation of selected alloys under simulated service conditions both by static exposure in the specified environment (at UPM) and by dynamic exposure in a specialized corrosion test loops (in Austria) (Table 3).

Table 1. Participants in UPM–Austrian Joint Research Project

Saudi Arabia	University of Petroleum and Minerals, Dhahran, (UPM); National coordinator Vice Rector F. H. Dakhil; Departments of Chemistry and Mechanical Engineering
Austria	ÖFZS—Austrian Research Center Seibersdorf, national coordinator Doz. Dr. P. Koss; VEW—Vereinigte Edelstahlwerke—United Stainless Steel Works, Ternitz and Kapfenberg; VA—VÖEST Alpine Linz, VÖEST-Alpine Steel Works, Linz; VMW—Vereinigte Metallwerke Ranshofen-Berndorf—United Non-Ferrous Metal Works, Ranshofen; MUL—Montanuniversität Leoben, Montan University Leoben, Institut für Allgemeine und Analytische Chemie; UW—Universität Wien—University of Vienna, Institute of Materials Science

During the subsequent investigations particular attention was given to the specific environmental conditions prevalent in Saudi Arabia. In addition, a field test-rig was constructed by an Austrian company (VEW), suitable for placement in the coastal waters in the Arabian Gulf near Dhahran. After completion the massive test-rig was presented by the Austrian Minister of Science and Research, Dr. Hertha Firnberg, to Vice-Rector F. H. Dakhil as the representative of UPM, in a symbolic gesture to underline the spirit of cooperation. This field test station provides space for more than 200 plate-shaped specimens to be exposed either totally submerged or in the splash zone of the sea water over periods of several years.

Table 2. Objectives and Task Groups of Phase I of the Joint Research Project

Objectives*	Cooperating partners
— Develop methods for the measurements of: weight loss corrosion potential polarization resistance crevice corrosion susceptibility	UPM, VEW, VA, VMW
— Develop suitable corrosion fatigue test procedures†	UPM, MUL, UW
— Perform microcharacterization by electron optical methods of as-received and corrosion tested samples	UPM, ÖFZS, UW

* Types of test methods, experimental procedures, and alloys proposed by VA, VMW; VEW (low-C steel St. 14.05, austenitic stainless steel type AISI 316L, and pure Al 99.5).

†Specimen geometry, surface preparation, and etch procedures selected by MUL and UW; specimen materials recommended by VEW and VMW.

Table 3. Objectives of Phase II and III of the Joint Research Project

- Design, construction, and installation of a field test-rig at a beach site near Dhahran, by VEW; selection of materials for initial set of test samples by VA (low-C steel and 2 low alloy steels). VEW (12 types of stainless steels and various base-metal weld-metal combinations) and VMW (14 Al-alloys in 3 different surface conditions).
- Operation and servicing of the test rig by UPM, cooperative evaluation of test results after each sampling interval (UPM, VEW, VMW, VA).
- Static laboratory corrosion testing of selected salt-water resistant alloys in defined natural environments (by UPM) and corresponding synthetic salt water (by VEW), determination of pitting potentials of stainless steels by VEW, and weight loss and corrosion potential measurements of Al-alloys by VMW.
- Corrosion fatigue testing of selected alloys at room temperature in inert and aggressive solutions at MUL (stainless steels with increased Mo-content at a test frequency of 200 Hz), and at UW (same types of stainless steels and pure Al specimens at a test frequency of 20 kHz).
- Dynamic corrosion testing of selected steels in a test loop operated with synthetic sea water (at VA, C-steel, Cu-Cr-Ni-P and Cu, Cr, Ni, Nb low alloy steels).
- Microcharacterization at as-received and selected corrosion tested materials at UPM, ÖFZS and UW.

The results of the laboratory and field tests have been jointly evaluated by all the participating members and exhaustively documented in co-authored project reports [2, 3]. For the future, a continuation of the cooperative effort is planned including the evaluation of the corrosion resistance of selected materials in various brackish waters by means of a dynamic corrosion test loop.

The truly outstanding success of this international scientific and technological concerted action would not have been possible without the generous support of the governing bodies at UPM and the Austrian Ministry of Science and Research.

The participating scientific and engineering personnel have benefited from this cooperation by becoming familiar with particular economical, technological, and environmental situations. Moreover, it has also provided new opportunities for students of both nations to become witnesses of a constructive international interaction resulting in considerable mutual benefit.

The majority of the following papers were selected to exemplify some of the results of these cooperative projects. They represent also the current status of the applied research work of various task groups and should be judged on the basis of the outstanding value of their complementary activities.

REFERENCES

[1] Research Agreement between UPM and the Austrian Ministry of Science and Research.

[2] International Cooperation 'Corrosion of Steels and Al-alloys', final report phase I. *SGAE Report no. 2679*, Research Center Seibersdorf, A, (November 1976).

[3] International Cooperation 'Corrosion of Steels and Al-alloys', final report phase II. *SGAE Report No. A0011*, Research Center Seibersdorf, A. (December 1978).