Quantitative evaluation of the corrosivity of elastomeric compounds against stainless steels

D. BACCI, A. CAUTERUCCIO, P. MARTINIS, R. MIGOTTO
Industrie Zanussi Spa, Direzione Ricerche e Tecnologie, Viale Treviso 15, 33170 Pordenone, Italy

An electrochemical technique was applied to establish a quantitative procedure in the study of the corrosivity of elastomeric compounds against stainless steels. This technique was able to differentiate between the behaviour of different EPDM compounds in relation to three stainless steels (AISI 430, AISI 304, ELI "444"). Because of its speed and sensitiveness this method can be usefully applied in acceptance procedures.

1. Introduction

It is well known that elastomeric compounds in close contact with metallic materials and in certain environmental conditions (hot–wet) can promote corrosion attacks [1]. This is especially true in the case of gaskets, bellows, o-rings, etc., used to seal containers, even if made up with stainless steels. Reasons for this are to be found in the migration of products of elastomeric compounds, due to the composition and the technological parameters of processing.

The aim of this work was to set up an experimental procedure to evaluate quantitatively the corrosivity of elastomeric compounds against stainless steels. The procedure must be precise, reliable and quick. It is beyond the aim of this work to determine the causes of the chemical attack.

2. Experimental procedure and materials

Potentiodynamic anodic (forward and reverse) polarization measurements were performed at $2\,mV\,sec^{-1}$ and at room temperature. A standard calomel electrode (SCE) and a platinum counter-electrode were used.

The stainless steels specimens examined had a surface area of $18\,cm^2$ and were only degreased just before the measurements. The scan range was from -1 to $+2$ V (forward) and *vice versa* (reverse). The electrolyte was prepared by extraction using 200 g sample of the elastomeric compound to be examined and 500 ml of deionized water.

Laboratory comparative life tests were performed by putting specimens of the elastomeric compound to be tested between two sheets of AISI 430 stainless steel. These samples were kept in climatic cells for 96 h at $40 \pm 2^\circ$ C and with 100% relative humidity.

Optical examination was performed to detect pitting. Six different EPDM elastomeric compounds were tested in contact with the following three grades of stainless steels: a ferritic AISI 430, an austenitic AISI 304 and a ferritic "extra low interstitials" (ELI)444, at a commercial surface finish (2B).

3. Results and discussion

In Fig. 1 the potentiodynamic scans for six different compounds with test specimens of AISI 430 are shown. It must be noted that linear plots are used as compared to more common semilogarithmic plots. This was due only to computing reasons.

The behaviour of the six compounds can be seen to be different, just by looking at this graph, but for a quantitative evaluation the areas enclosed by the six reverse branches were computed. This is the same as computing the total charge flow in the process.

Looking only at the reverse polarization branch one takes into account the overall characteristics

0022–2461/82/113239–04\$02.98/0

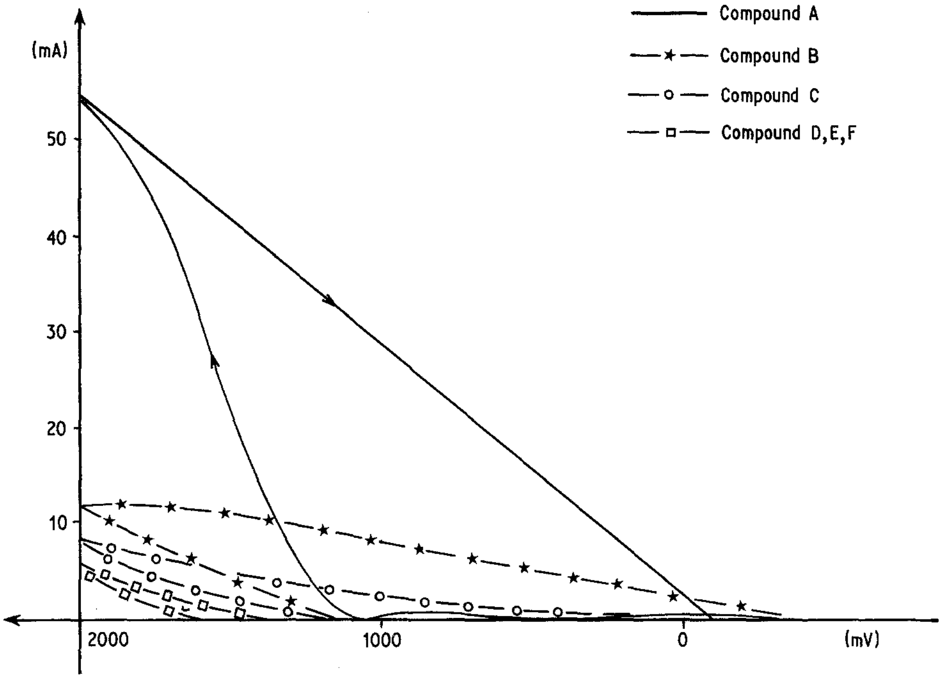

Figure 1 Summary of potentiodynamic scans (six elastomeric compounds, A to F, against AISI 430).

of the system tested, i.e., pitting and crevice properties [2, 3]. A comparison between the tested elastomeric compounds from the computed areas (from now "corrosivity index") is reported in Fig. 2, from which it appears that a significative difference exists between compound "A" and the other five. These results are in agreement with the laboratory life tests (see Table I). It was observed that the corrosivity index shown for compound "B" was the upper limit, beyond which the first localized attacks appeared in the laboratory life tests. Therefore this level was assumed to be the acceptance level, as shown in Fig. 2.

TABLE I Laboratory life tests results

Compound	Evaluation
A	Pitting
B	No corrosion
C	No corrosion
D	No corrosion
E	No corrosion
F	No corrosion

Referring to the same elastomeric compound it was noted that wide fluctuations are to be expected by changing the production stock; in addition in the tested AISI 430, a clear difference is observed from stock to stock. These results are reported in Fig. 3.

By using the most corrosive elastomeric compound, the performances of AISI 304 and ELI "444" were tested. The latest is a non-conventional stainless steel, so a chemical analysis, as supplied by the producer, is given in Table II.

The behaviour of these stainless steels is shown in Fig. 4. As expected, the performance of AISI 304 is much better than that of AISI 430; ELI "444" is also seen to be roughly as good as AISI 304.

It can be suggested that one can use this technique for a quick acceptance test, not only for elastomeric compounds but also for different grades of stainless steels. The acceptance level of the corrosivity index is, in every case the same as shown in Fig. 2, depending only upon the simulative laboratory life tests initially employed.

TABLE II Chemical composition of ELI "444"

C	Mn	Si	P	S	Ni	Cr	Mo	Ti	Nb	N
0.013	0.25	0.26	0.028	0.009	0.12	18.00	1.95	0.08	0.35	0.017

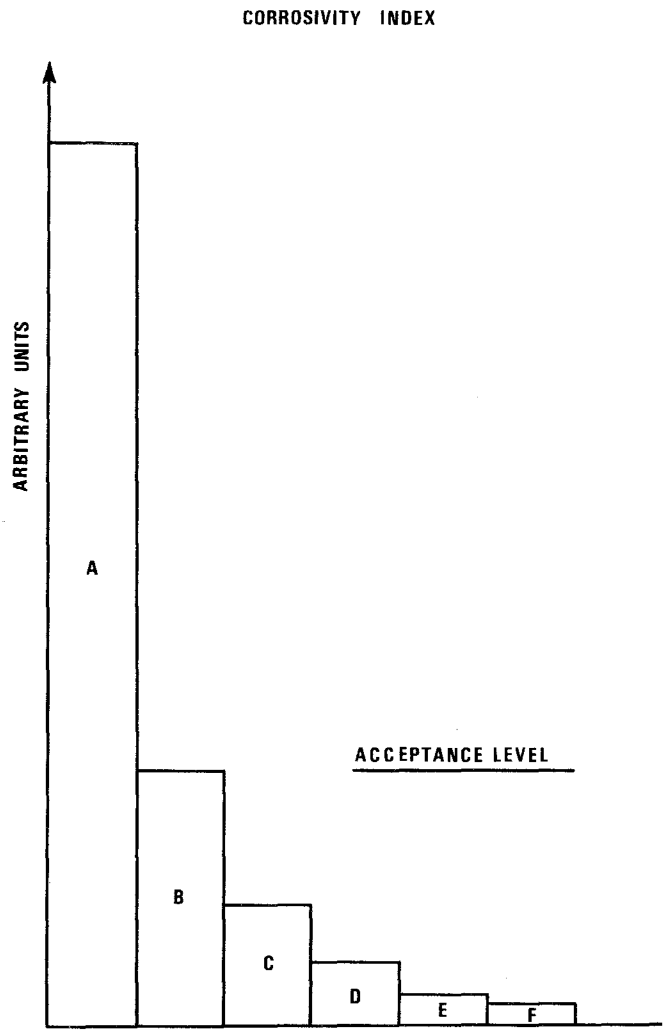

Figure 2 Corrosivity index of the six elastomeric compounds tested against AISI 430.

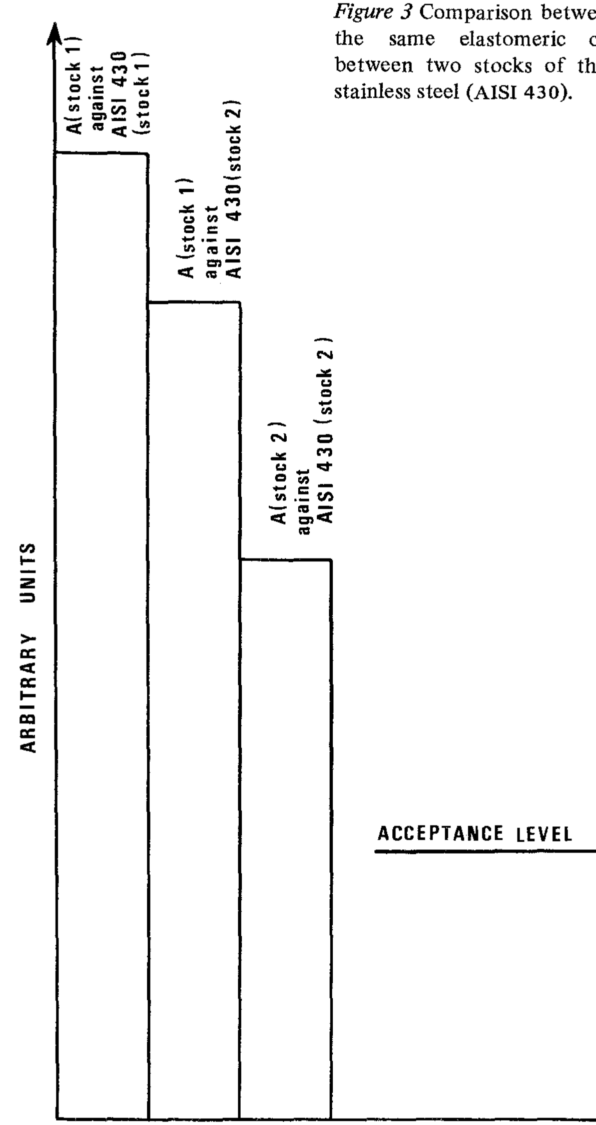

Figure 3 Comparison between two stocks of the same elastomeric compounds and between two stocks of the same grade of stainless steel (AISI 430).

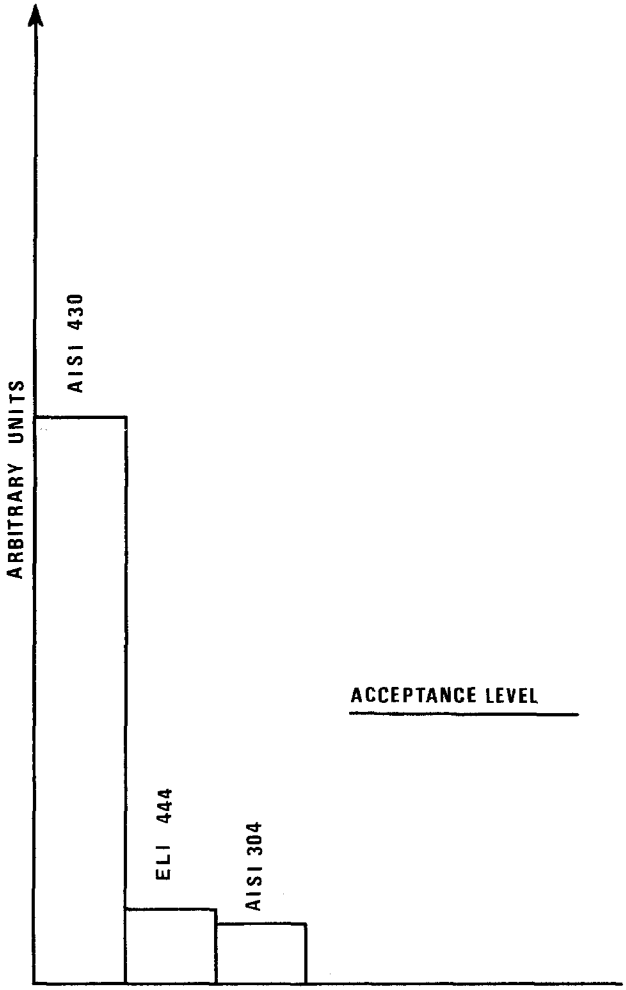

Figure 4 Performance of three different grades of stainless steels against the most corrosive compound.

4. Conclusions

By using standard electrochemical tests, a useful parameter (corrosivity index) was defined to evaluate the corrosion properties of elastomeric compounds when employed in conjunction with stainless steel sheets. This index allows one to distinguish not only among different elastomeric compounds, but also among different production stocks. This also holds for different grades of stainless steels (AISI 430, AISI 304, ELI "444"), when tested with a standard elastomeric compound.

The results obtained are in good agreement with the laboratory life tests.

References

1. Unilever (Research-Port Sunlight), Technical Report No. 3883 (1980).
2. Z. SZKLARSKA-SMIALOWSKA and M. J. CZACHOR, *Corros. Sci.* 11 (1971) 901.
3. E. L. LIENING, *Mater. Performance* 19 (1980) 35.

Received 5 February
and accepted 23 April 1982