Stress Corrosion Cracking of Stainless Steel Canister of Concrete Cask

Central Research Institute for
Electric Power Industry

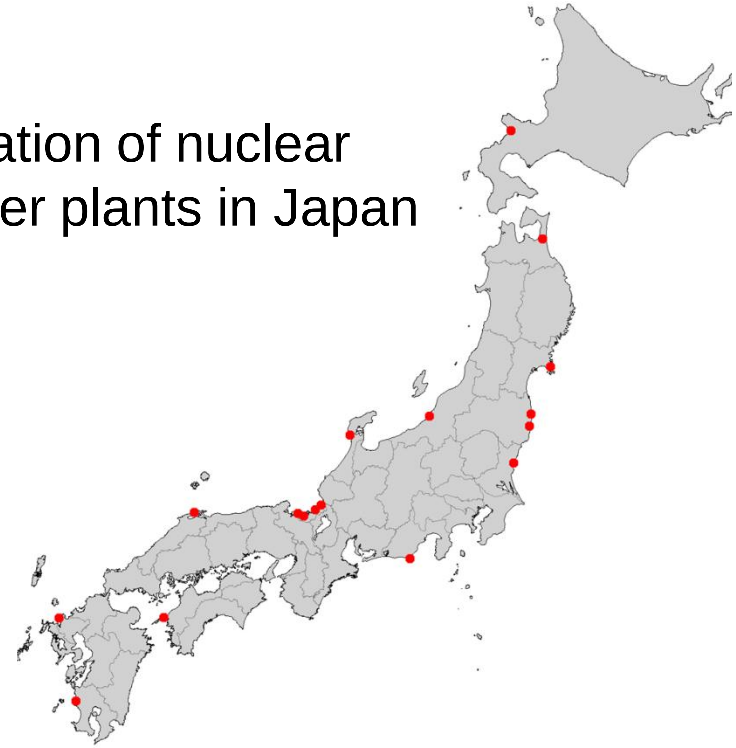
J. Tani, K. Shirai, M. Wataru and T. Saegusa

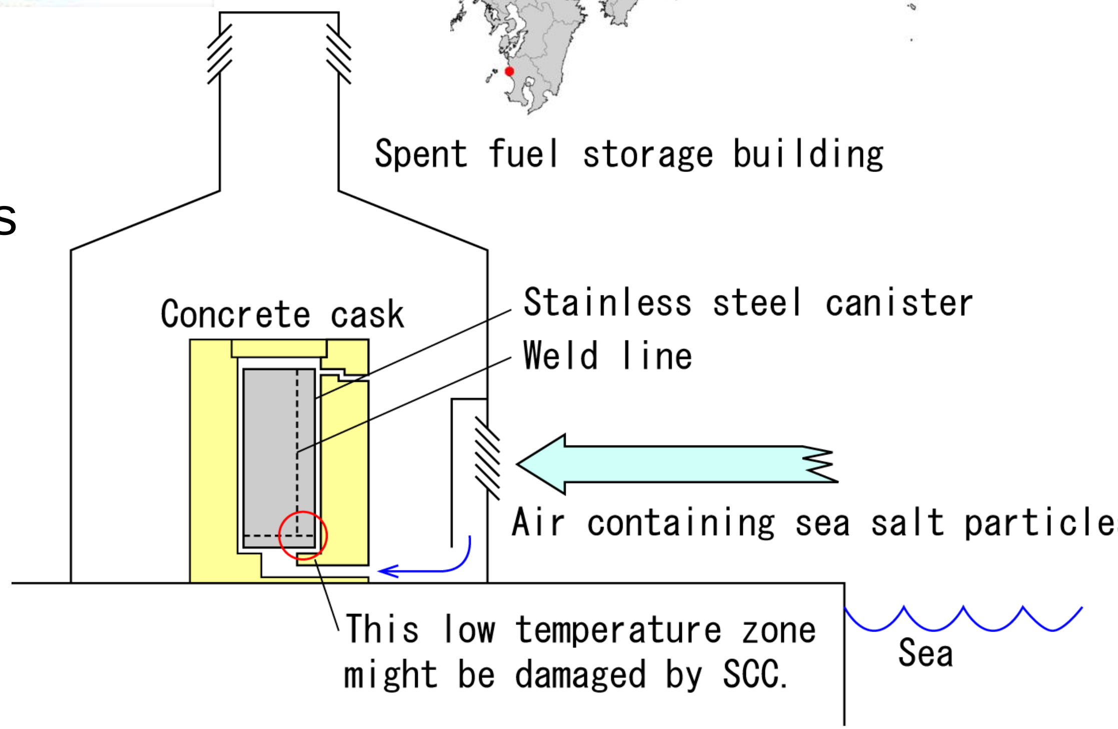
This work has been carried out under the contract from NISA/METI.

Background

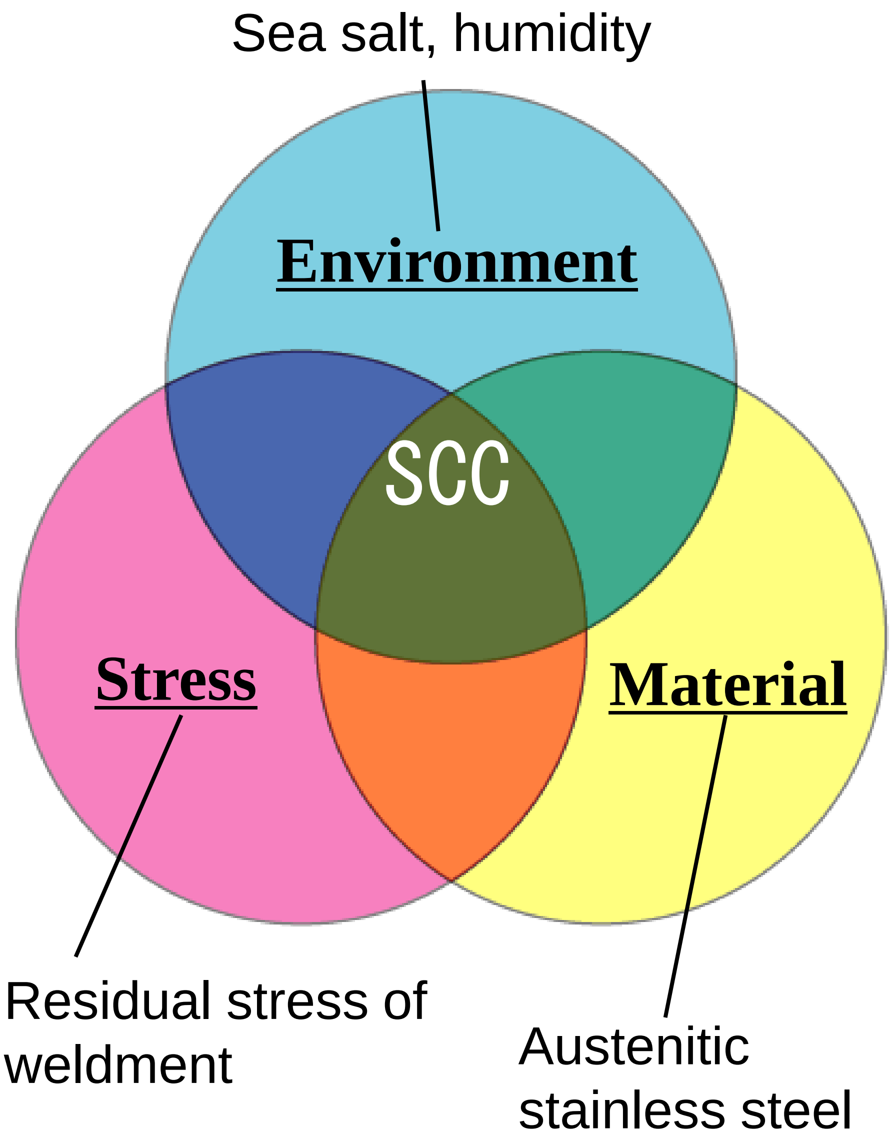
Chemical plants at costal regions have been experienced external stress corrosion cracking (ESCC) by air containing sea salt.

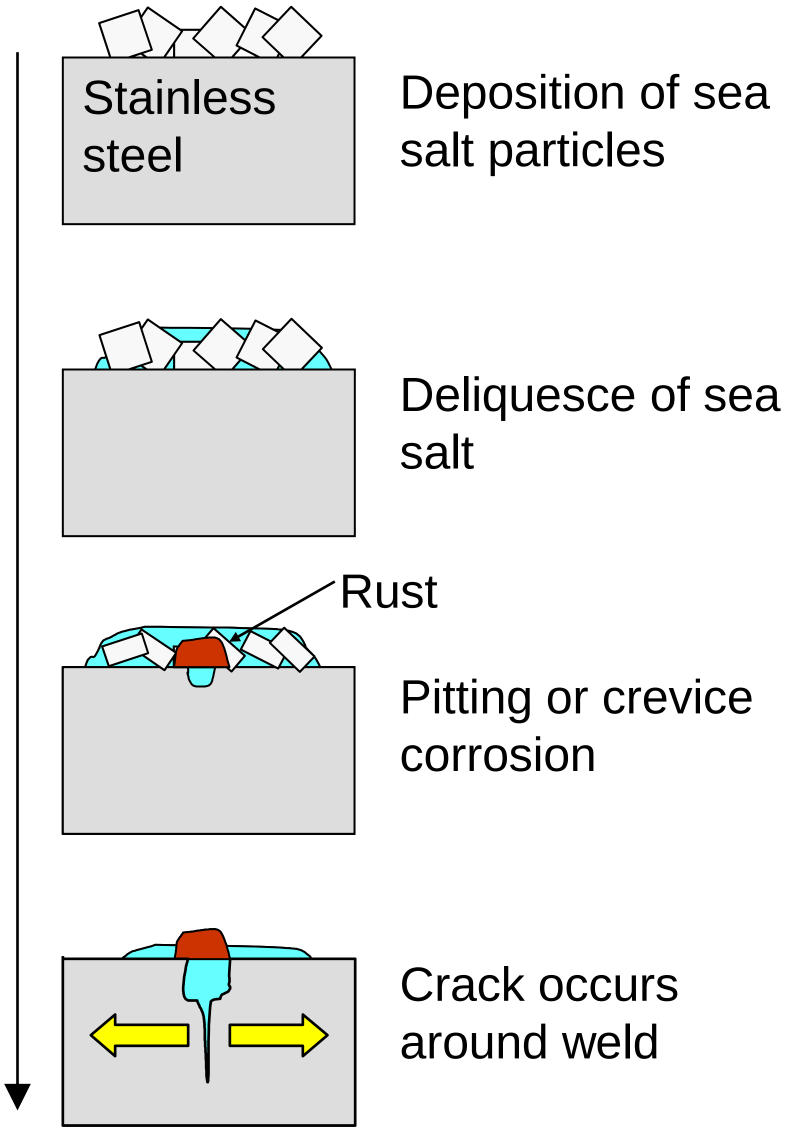
Location of nuclear power plants in Japan





Stress Corrosion Cracking





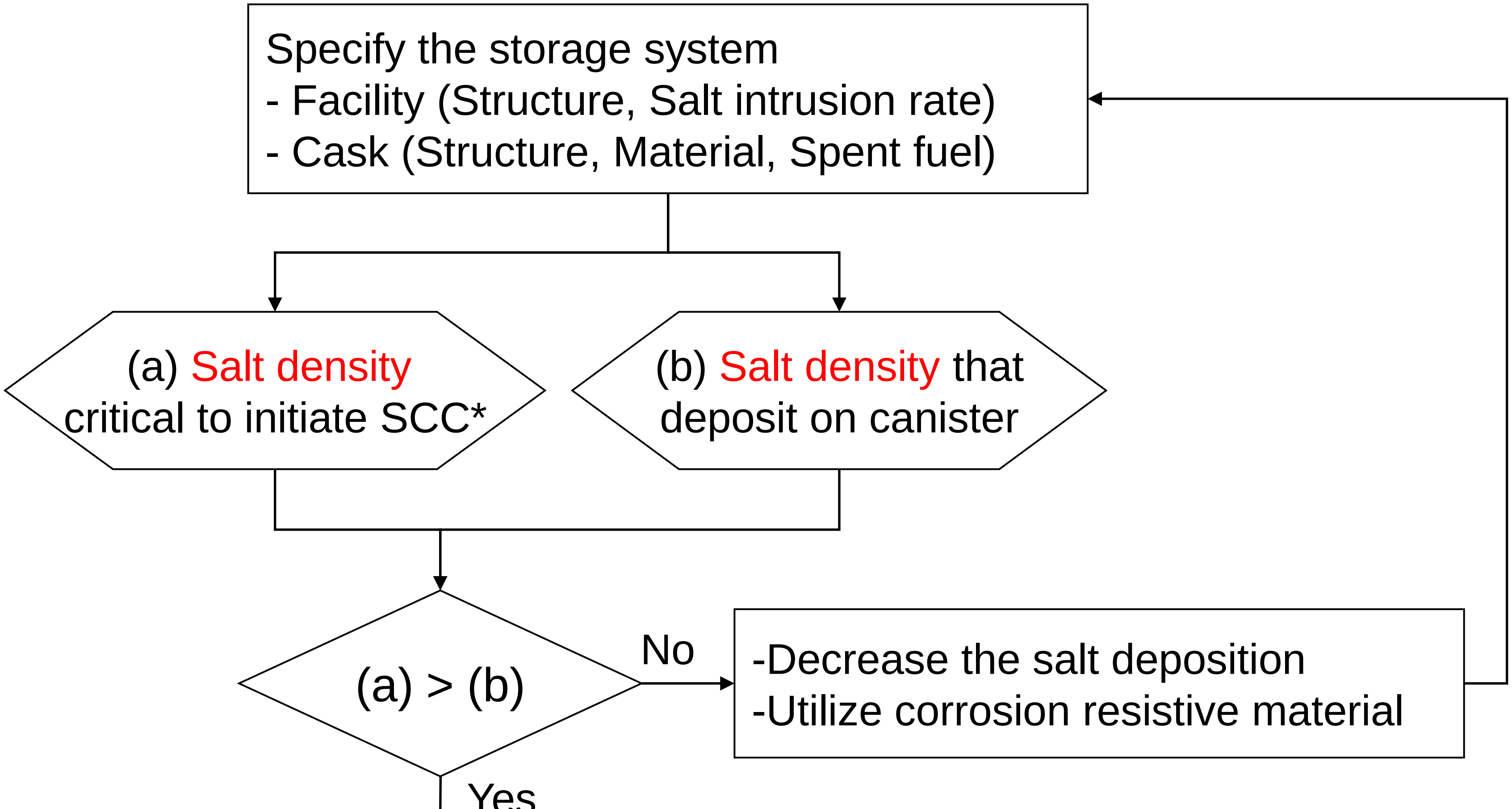
SCC mitigation

- Environment
  - Keep Cl density lower than threshold value
  - SCC does not occur at lower than threshold temperature or threshold relative humidity
- Material
  - High chromium or high molybdenum steel
- Stress
  - Stress relaxation / Compressed stress

Crack growth evaluations

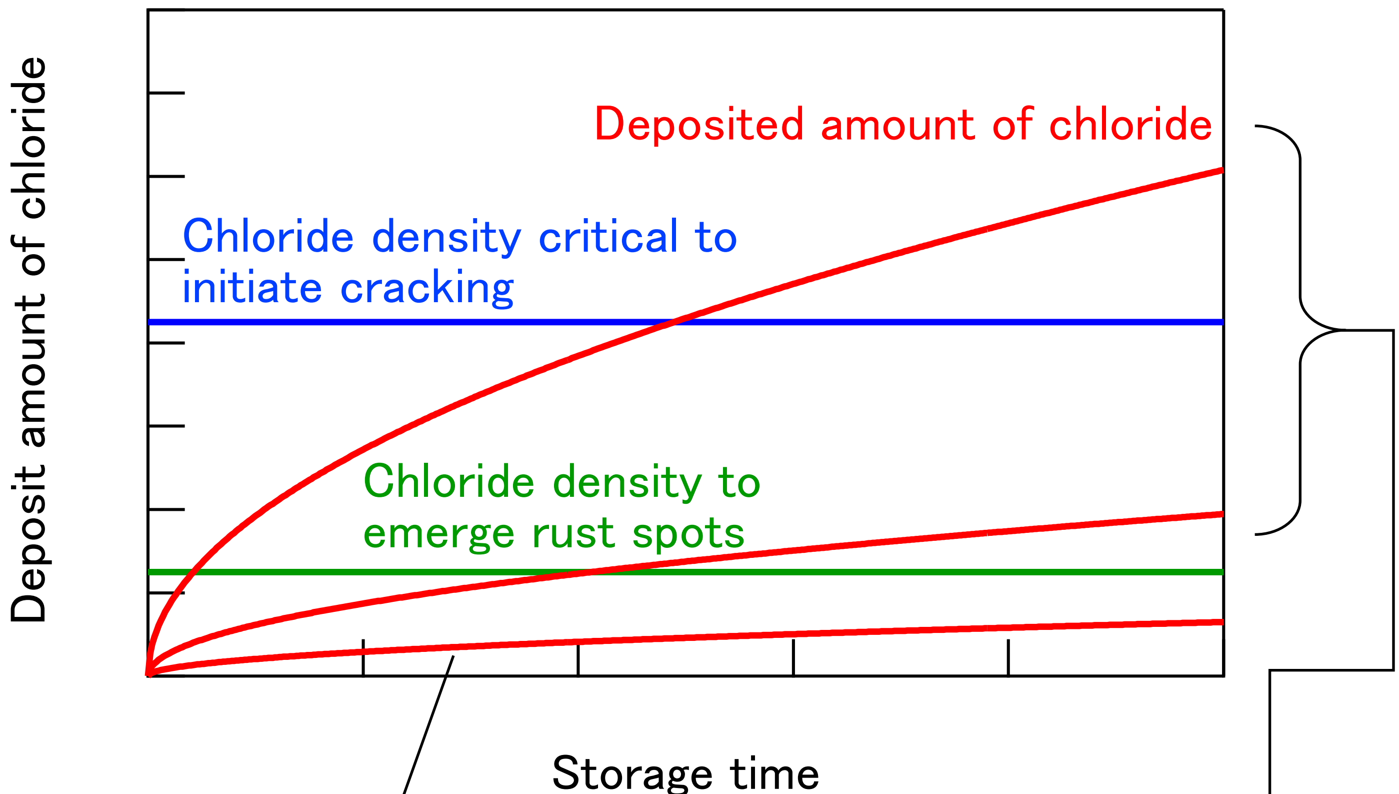
- Crack growth measurement with CT specimen or 4point bend specimen
- Atmospheric SCC almost do not depend on K value, so crack length depends on operation time.
- Considering threshold relative humidity for SCC, constant crack growth during all the storage period seems conservative.

Environmental requirement



* Initiation of SCC is defined as follows
- Emerge of rust (precursor of cracking)
- Initiation of small crack

Assessment for design



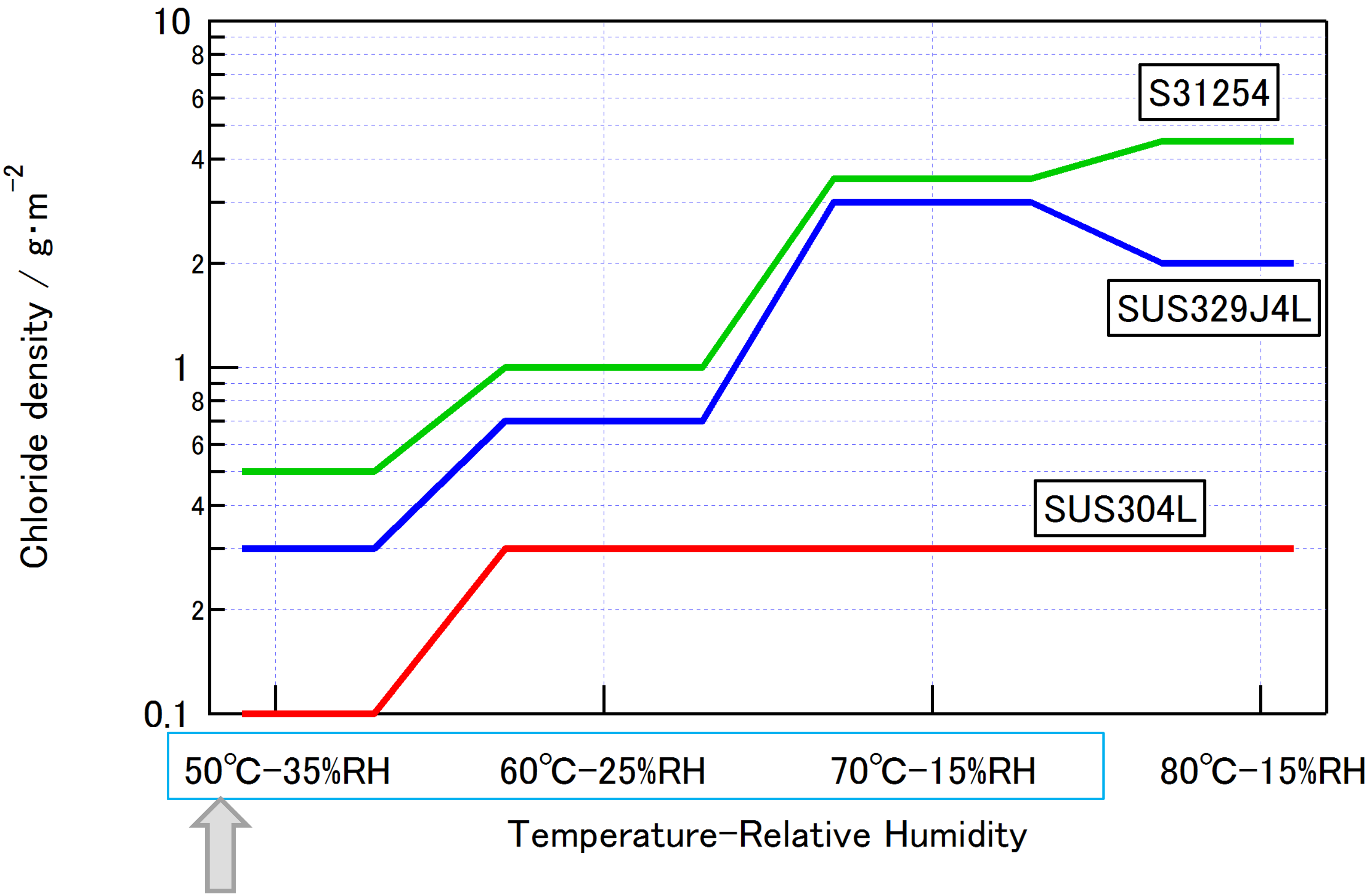
Proper design

Modification is required to:

•Decrease salt deposition

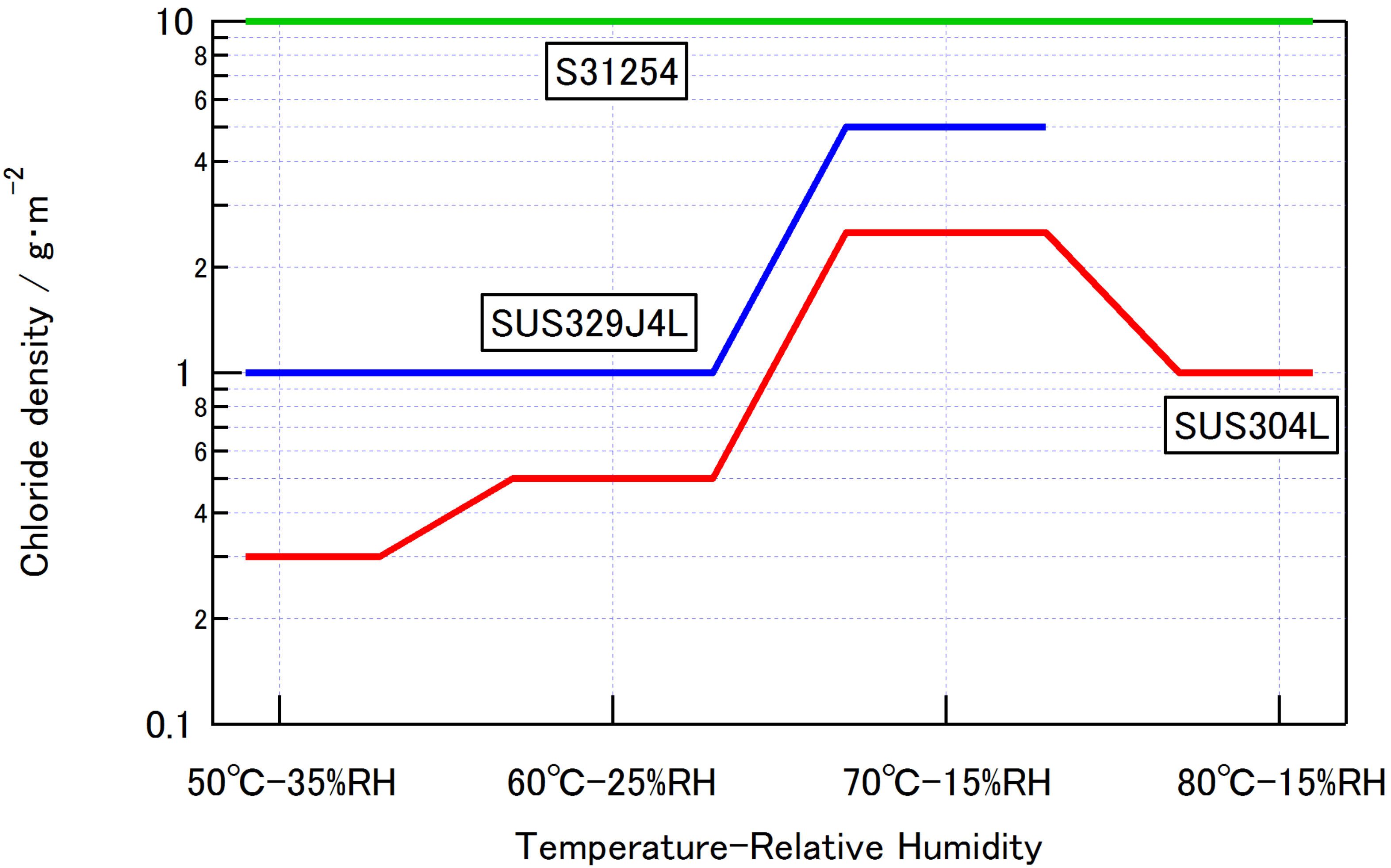
•Increase threshold for corrosion
(change of material for canister)

Chloride density for Rusting



Satisfy absolute humidity of $30 g/m^3$

Chloride density for Cracking



Yield stress was applied on specimens.

Threshold Cl density for SCC

Material	Rusting	Cracking	PRE*
S30403	0.1	0.3	18.3
S31260	0.3	1	37.8
S31254	0.5	10**	43.3

(g/m^2 as Cl)

* PRE=%Cr+3.3×(%Mo)+16×(%N)

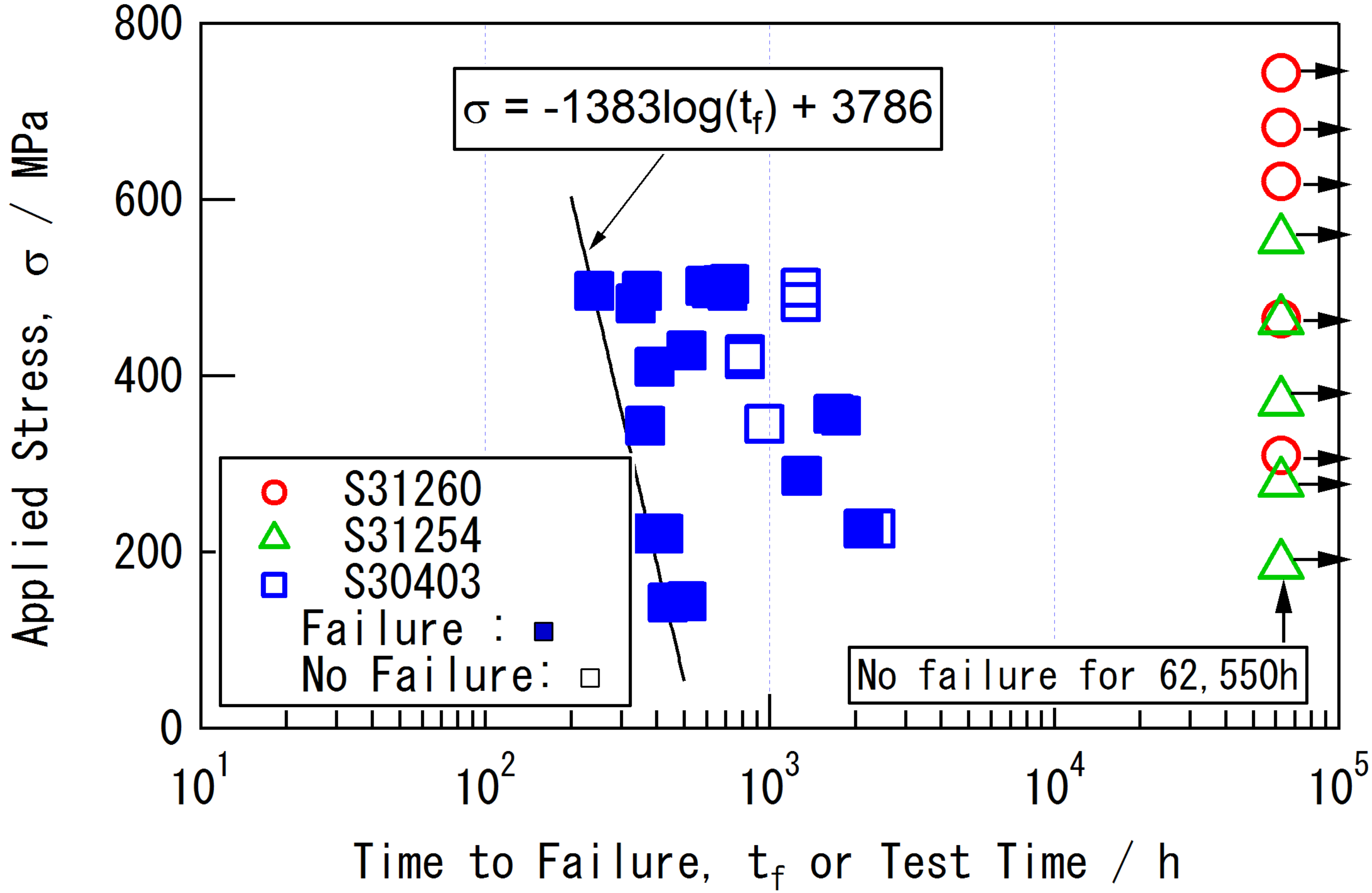
** Maximum test condition, no SCC observed

	C	Si	Mn	P	S
UNS S30403	<0.030	<0.75	<2.00	<0.045	<0.030
UNS S31260	<0.030	<0.75	<1.00	<0.030	<0.030
UNS S31254	<0.020	<0.80	<1.00	<0.030	<0.010

	Cu	Ni	Cr	Mo	N
UNS S30403	–	8.00–12.00	18.00–20.00	–	<0.10
UNS S31260	0.20–0.80	5.50–7.50	24.00–26.00	2.50–3.50	0.10–0.30
UNS S31254	0.50–1.00	17.50–18.50	19.50–20.50	6.00–6.50	0.18–0.22

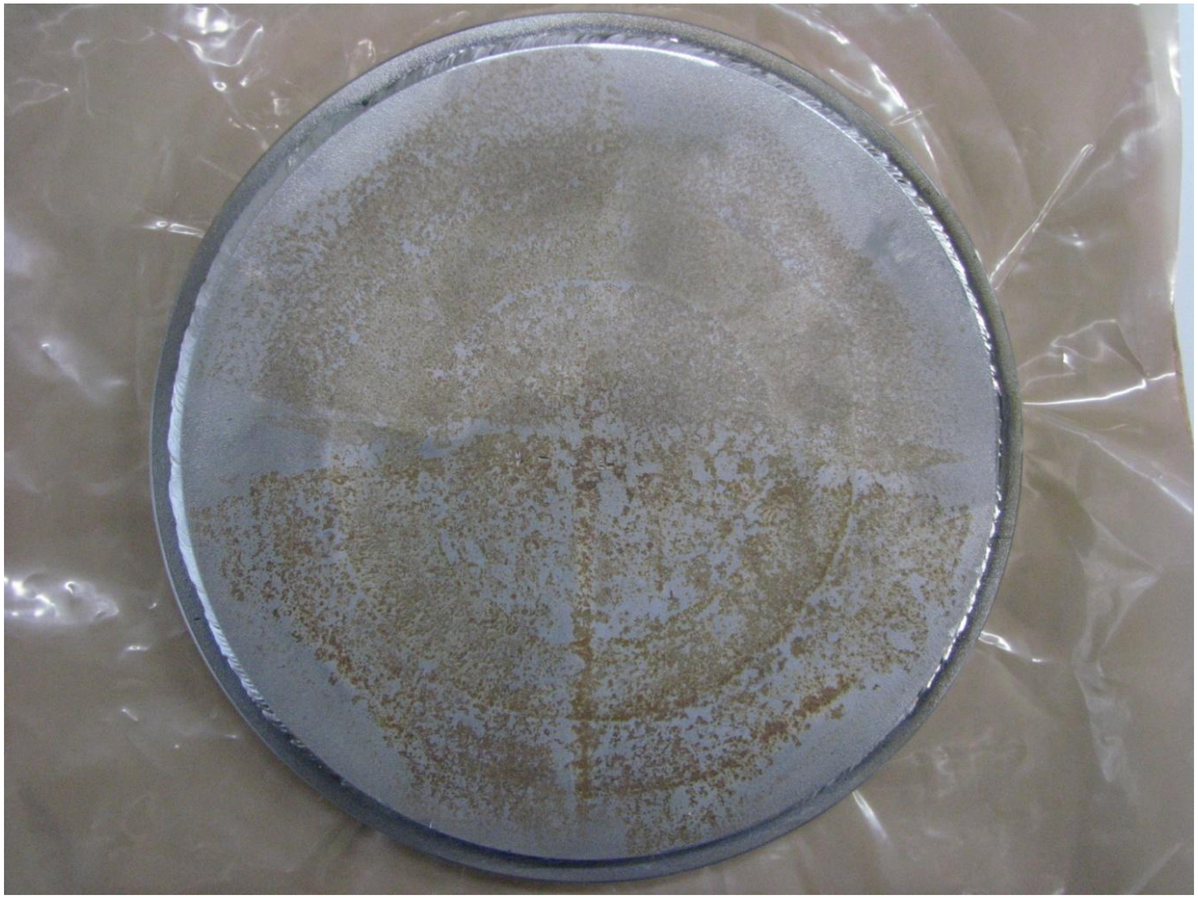
(wt%)

SCC resistant material



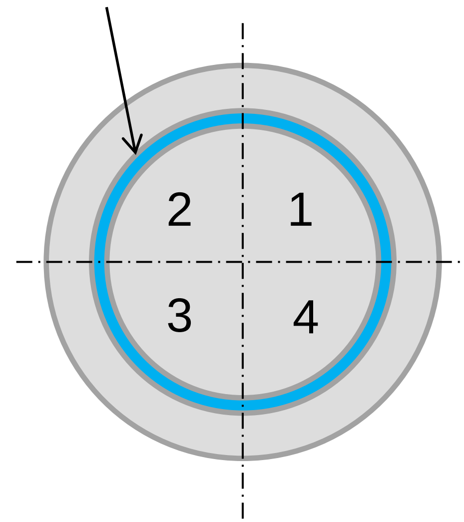
Test condition: 80C, 35%RH, 10g/m² as Cl(sea salt)

Experiment for residual stress relaxation



This specimen has no stress relaxation.

Weld (TIG, Laser)

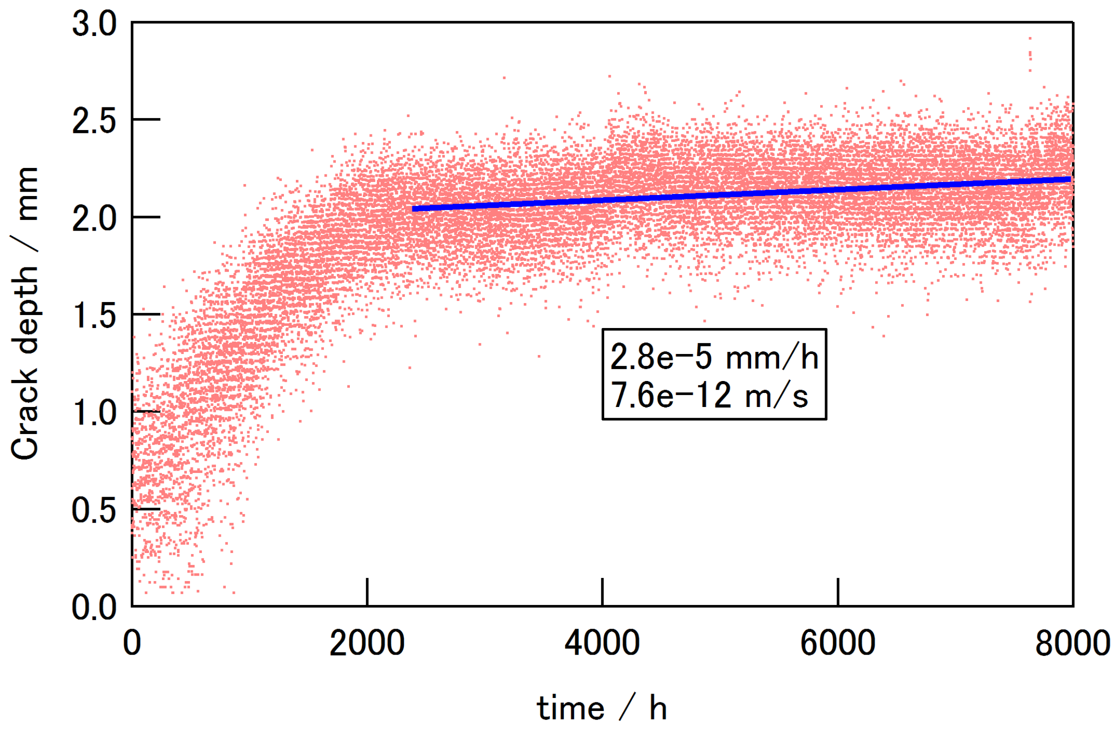


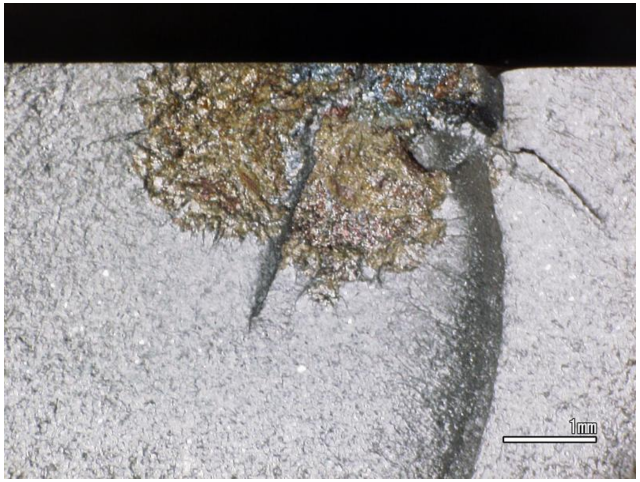
(Unit: g/m^2 as Cl)

After 2000h in 50C, 35%RH

Crack Growth Test

4 point bend test
Type 304 stainless steel, 80C, 35%RH, 270MPa
About 10g/m^2 as Cl of sea salt





Potential drop data was converted to crack depth data, assuming half elliptical crack propagated.

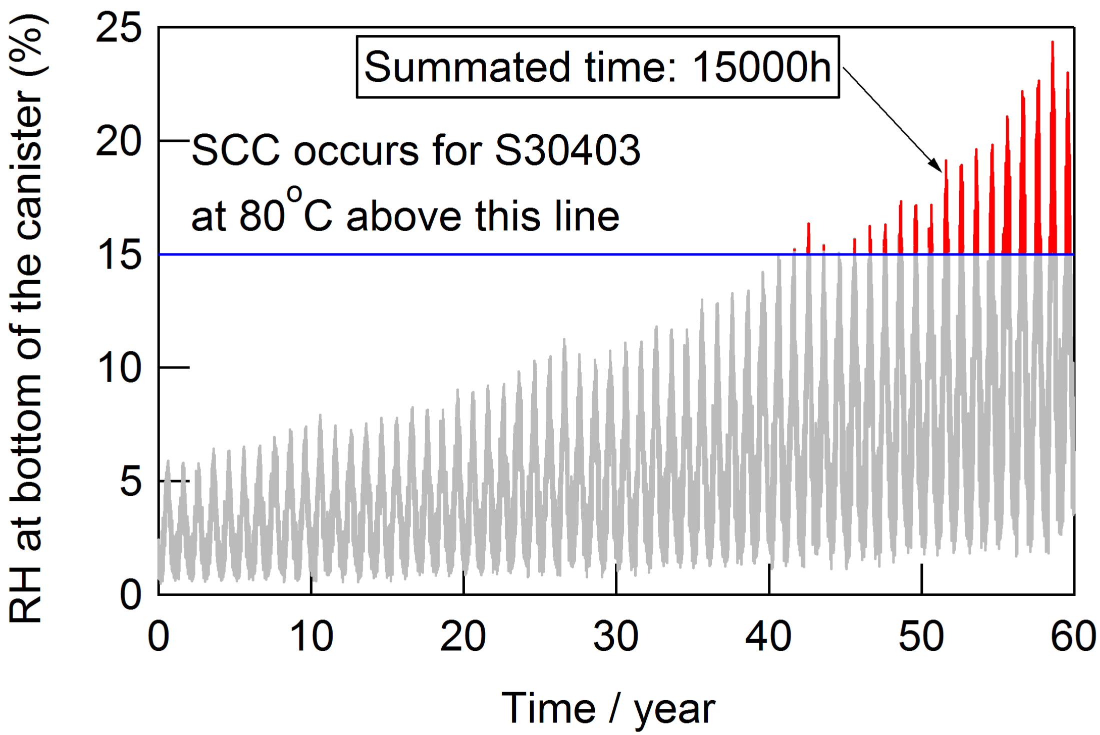
Example of crack growth evaluation

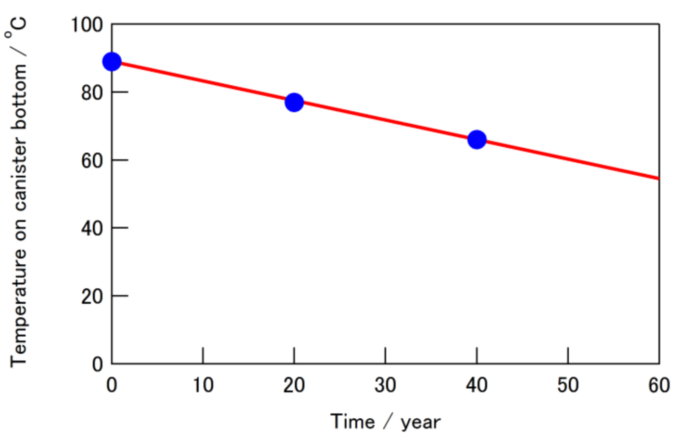
Calculated RH with data from Tsuruga weather station and data of heat decay test with model canister.

CGR: $1x10^{-11}$m/s

19mm / 60years

0.5mm / 15000h





Heat decay of canister surface

Summary

- Threshold chloride density for SCC is obtained.
- SCC resistivity of high chromium, high molybdenum stainless steels are shown.
- Stress relaxation test is in progress.
- Taking into account of environmental condition, crack growth evaluation suggests that crack do not penetrate canister wall.