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The regulatory position in Sweden concerning Ageing Management as of Spring 2005

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S-106 58 STOCKHOLM

Disposition

Background

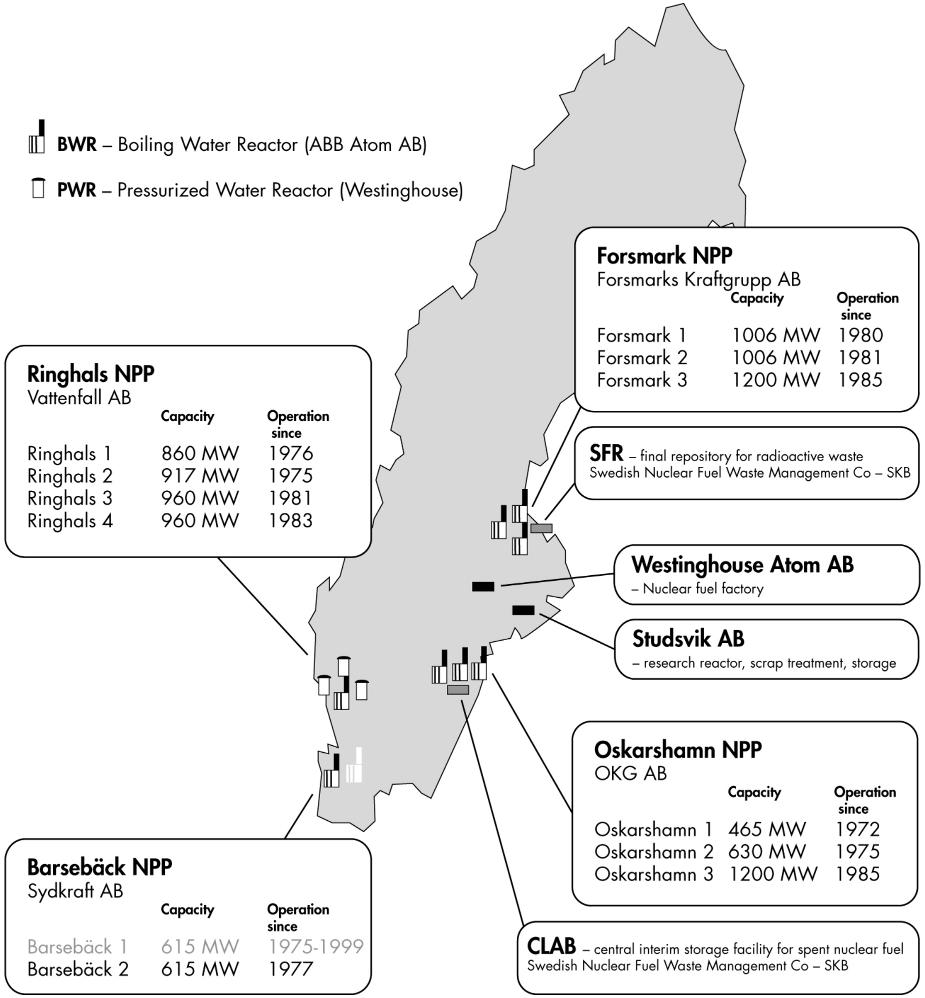
Regulatory situation

STRYK – a degradation database

Some examples of how STRYK can be used

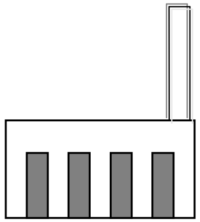
Concluding remarks

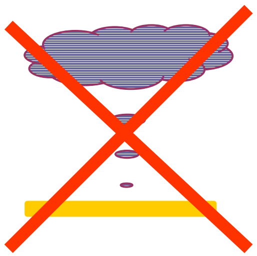
Background

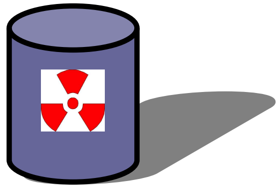

BWR – Boiling Water Reactor (ABB Atom AB)
PWR – Pressurized Water Reactor (Westinghouse)
Forsmark NPP
Forsmarks Kraftgrupp AB
Capacity Operation since
Forsmark 1 1006 MW 1980
Forsmark 2 1006 MW 1981
Forsmark 3 1200 MW 1985
Ringhals NPP
Vattenfall AB
Capacity Operation since
Ringhals 1 860 MW 1976
Ringhals 2 917 MW 1975
Ringhals 3 960 MW 1981
Ringhals 4 960 MW 1983
SFR – final repository for radioactive waste
Swedish Nuclear Fuel Waste Management Co – SKB
Westinghouse Atom AB
– Nuclear fuel factory
Studsvik AB
– research reactor, scrap treatment, storage
Oskarshamn NPP
OKG AB
Capacity Operation since
Oskarshamn 1 465 MW 1972
Oskarshamn 2 630 MW 1975
Oskarshamn 3 1200 MW 1985
Barsebäck NPP
Sydkraft AB
Capacity Operation since
Barsebäck 1 615 MW 1975-1999
Barsebäck 2 615 MW 1977
CLAB – central interim storage facility for spent nuclear fuel
Swedish Nuclear Fuel Waste Management Co – SKB

About SKI…

- State authority founded in 1974.
- Reports to the Ministry of the Environment.
- Financed through levies paid by the nuclear power companies.
- 55% for administration & 45 % for research
- 115 employees.







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Regulatory situation

Swedish Nuclear Power
Inspectorate Regulatory Code

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ISSN 1400-1187

SKIFS 1998:1

The Swedish Nuclear Power Inspectorate's Regulations Concerning Safety in Certain Nuclear Facilities

General Recommendations Concerning the Application of the Swedish Nuclear Power Inspectorate's Regulations above

Decided on August 11, 1998

(In all cases concerning interpretation the Swedish version takes precedence.)

SKIFS 2004:1

Umbrella regulations

an ageing management programme shall be prepared and submitted to SKI by 2005-12-31

any deficiency in defence in depth shall be evaluated, classified and reported

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Regulations – SKIFS 2000:2 concerning mechanical components


Statens kärnkraftinspektions författningssamling

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ISSN 1400-1187

SKIFS 2002:1

Statens kärnkraftinspektions föreskrifter om säkerhet vid slutförvaring av kärnämne och kärnavfall

Allmänna råd om tillämpningen av Statens kärnkraftinspektions föreskrifter enligt ovan

Beslutade den 24 oktober 2001

More specific than 2004:1; but still very general

Requires inspection and testing other programmes to ensure structural integrity

Only qualified inspection and repair procedures permitted

Report and investigate all degradation

Expand inspection sample up to 100 % if degradation found

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A qualitative ISI system has been used:

Consequence index (CI) is a qualitative measure of the likelihood that degradation will result in :

- nuclear fuel damage
- damage to reactor containment tightness
- discharge of radioactivity

DI \ CI	1	2	3
I	A	A	B
II	A	B	C
III	B	C	C

Damage index (DI) is a qualitative measure of the likelihood that crack formation or other degradation will occur

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Damage index

Damage index is determined by the probable loads and environment relative the construction and material properties of the component

- Conditions that can result in damage ➩ DI=1
- Conditions not expected to result in damage ➩ DI=2
- Conditions with minimal loads and other benign conditions ➩ DI=3

Examples of experience based conditions for assigning DI 1:

General

- **Mixing flows with ΔT>100°C**
- **Occurrence of high vibrations**
- **……………**

In environment where SCC cannot be excluded

- **T>150°C and carbon content >0,004% in SS materials**
- **T>150°C and nickel base alloys (e.g. 182/600)**
- **………………**

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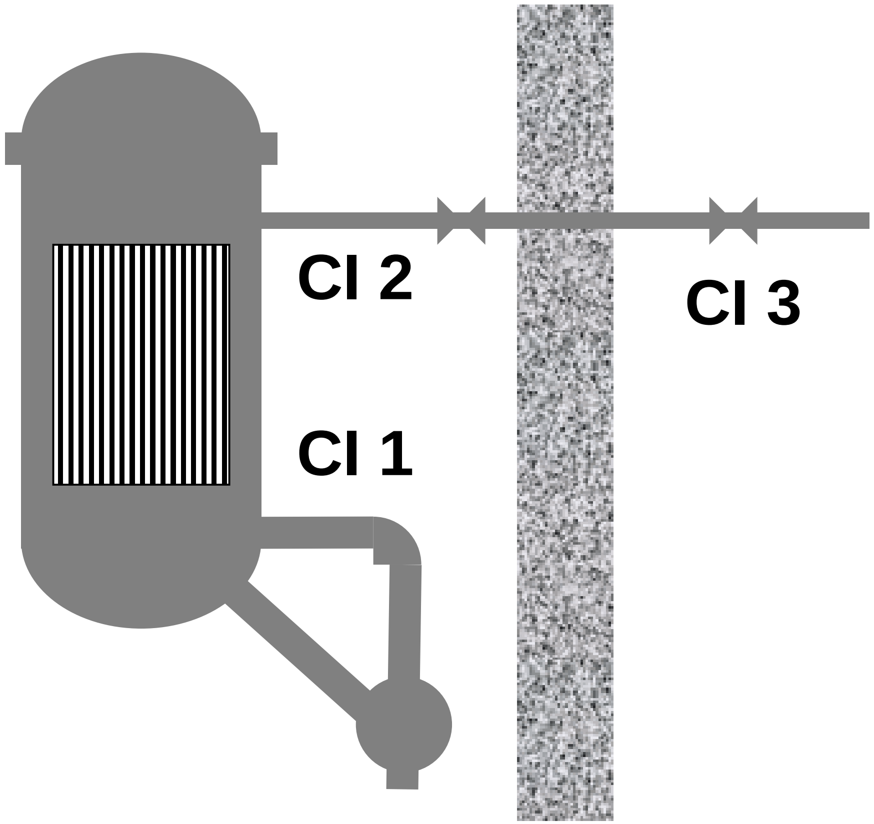
AUTORITE DE SURETE NUCLEAIRE

NuPEER 2005

Consequence index

Consequence index is determined by:

- pipe position relative to the core and valves that close automatic in event of break
- pipe dimensions
- system and thermal technical margins

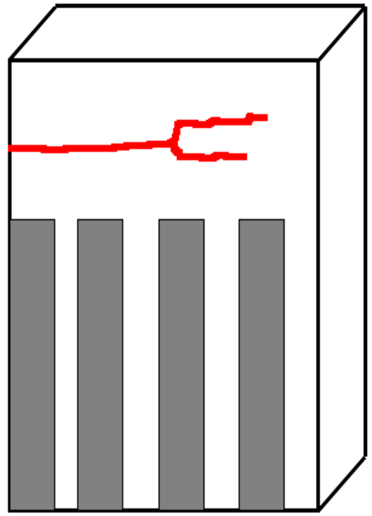


STRYK database

contains information on operationally induced degradation of barrier 3 in all Swedish NPP:s

not limited to piping, includes vessel internals, valves, etc.

1900 entries covering 1300 different events



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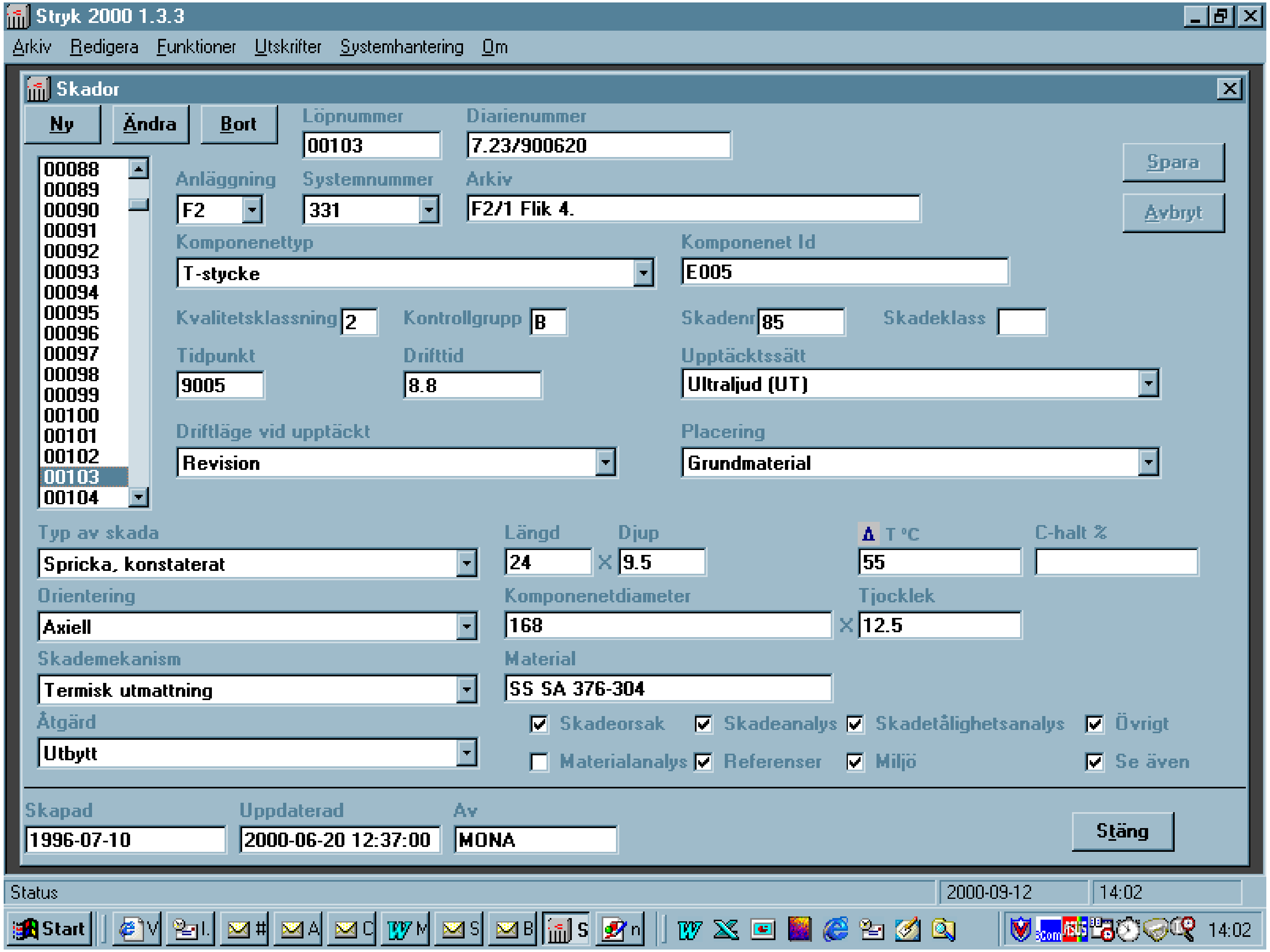
Stryk 2000 1.3.3
Arkiv Redigera Funktioner Utskrifter Systemhantering Om
Skador
Ny Ändra Bort
Löpnummer 00103
Diarienummer 7.23/900620
Spara
Avbryt
00088 00089 00090 00091 00092 00093 00094 00095 00096 00097 00098 00099 00100 00101 00102 00103 00104
Anläggning F2
Systemnummer 331
Arkiv F2/1 Flik 4.
Komponenettyp T-stycke
Komponenet Id E005
Kvalitetsklassning 2
Kontrollgrupp B
Skadenr 85
Skadeklass
Tidpunkt 9005
Drifttid 8.8
Upptäcktssätt Ultraljud (UT)
Driftläge vid upptäckt Revision
Placering Grundmaterial
Typ av skada Spricka, konstaterat
Längd 24
Djup 9.5
T °C 55
C-halt %
Orientering Axiell
Komponenetdiameter 168
Tjocklek 12.5
Skademekanism Termisk utmattning
Material SS SA 376-304
Åtgärd Utbytt
Skadeorsak Skadeanalys Skadetålighetsanalys Övrigt
Materialanalys Referenser Miljö Se även
Skapad 1996-07-10
Uppdaterad 2000-06-20 12:37:00
Av MONA
Stäng
Status 2000-09-12 14:02
Start 14:02

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Care needed for analysis

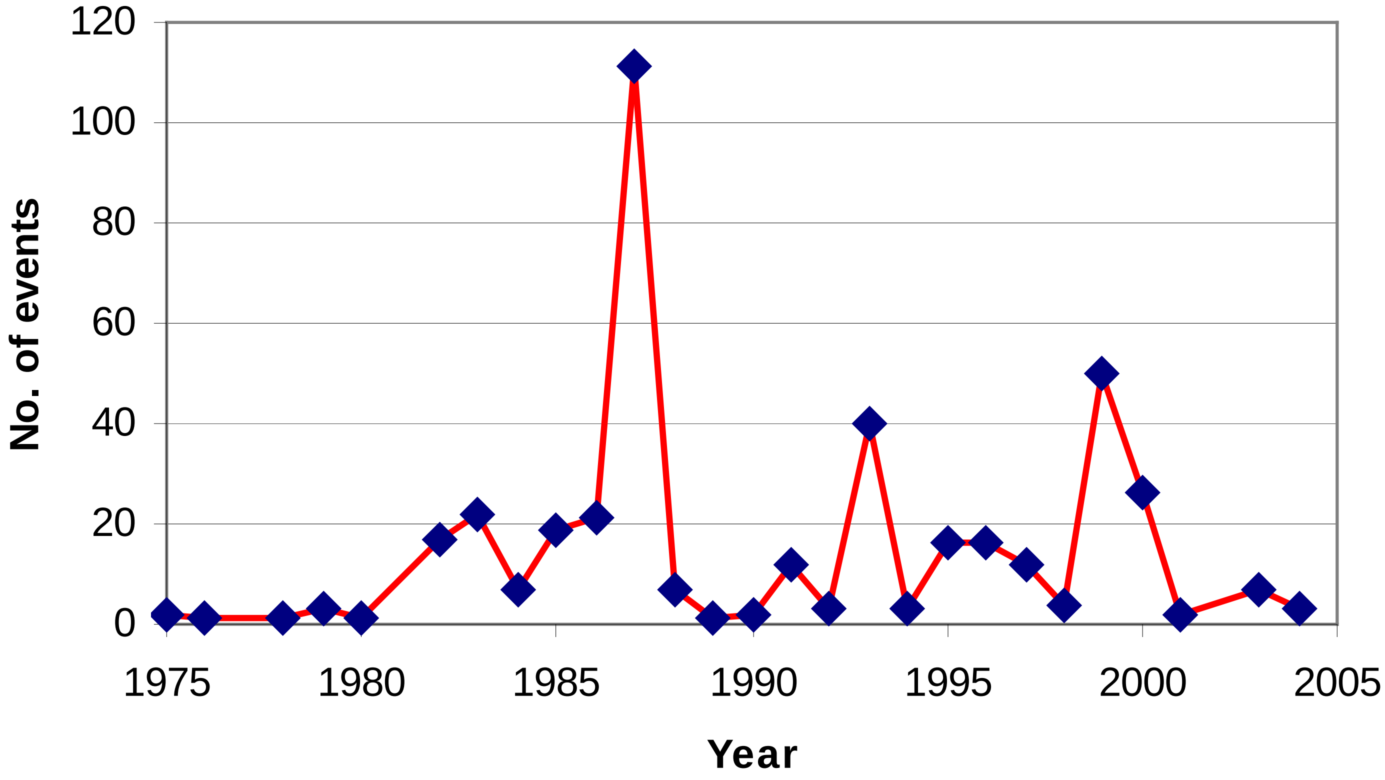
Quality of data variable

- reporting requirements have changed
- information not always to be found in plant archives

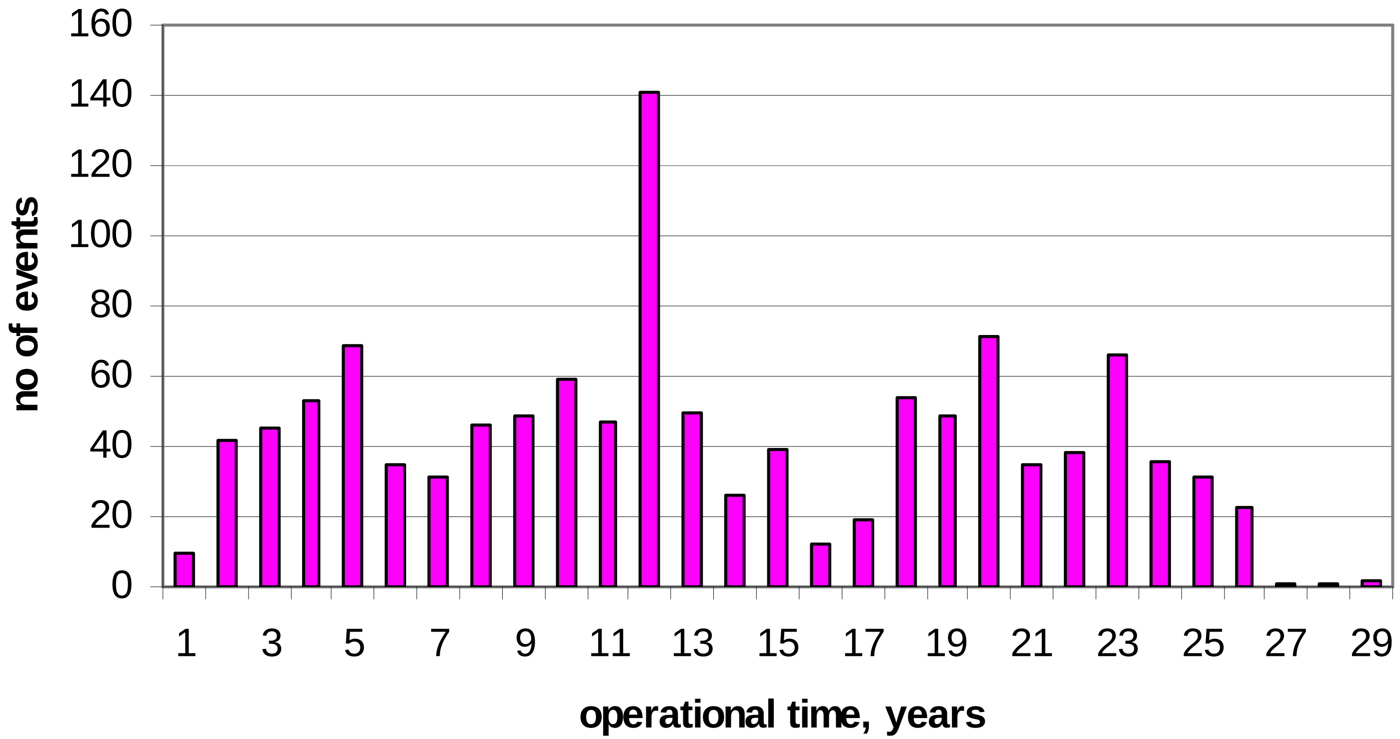
Time entered for an event is the time at which the event was found and reported and has therefore no direct relationship to the initiation time for the event

System numbering not consistent between plants and not sometimes not even for same event

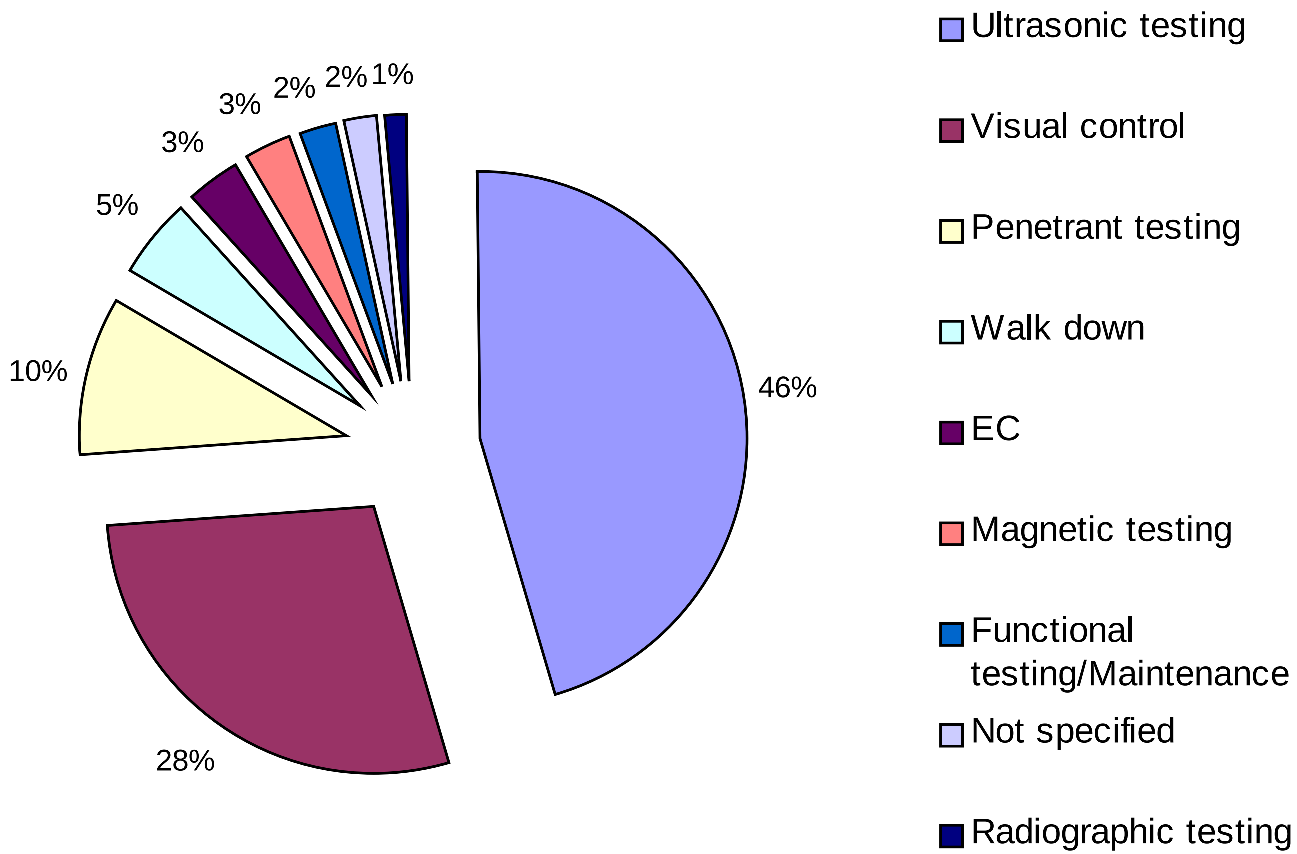
Events as a function of calendar time



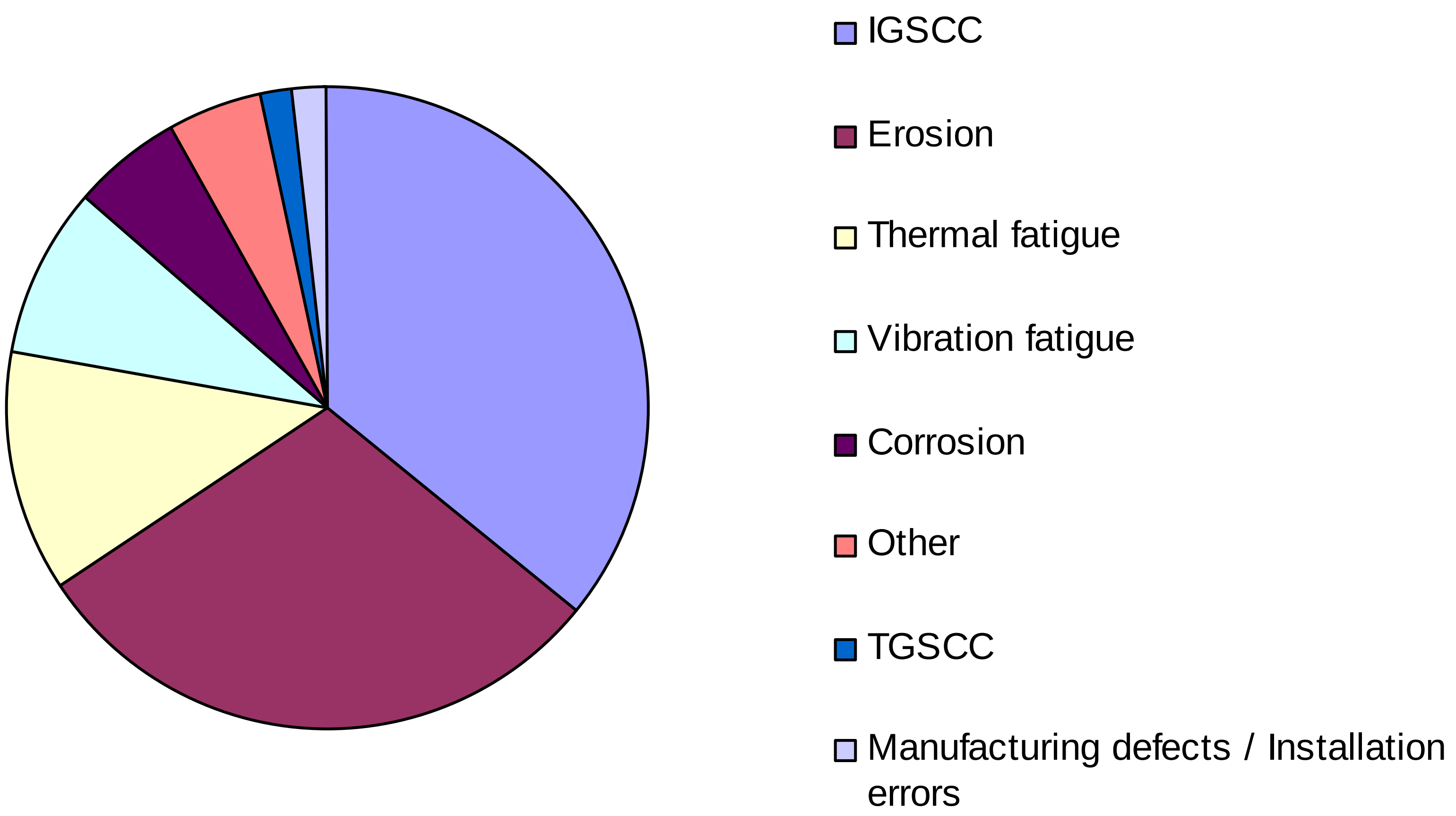
Events as a function of operational time



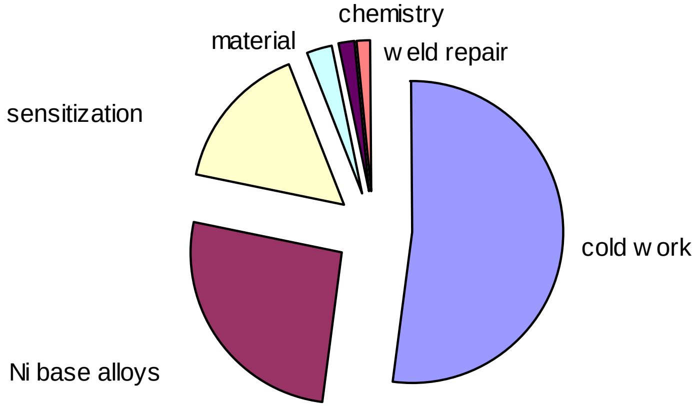
Detection method



Degradation mechanisms



IGSCC Main root causes



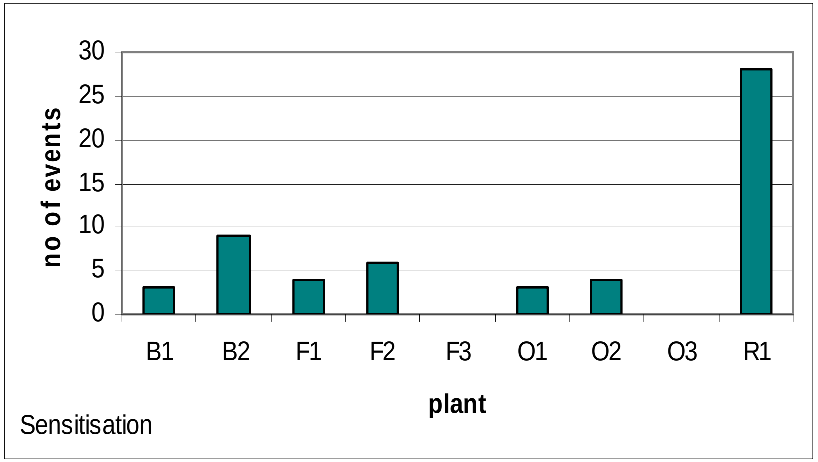
Somewhat subjective: many cases could be assigned to two or more categories. I have tried to make the choice on the basis of the information submitted by the plants.

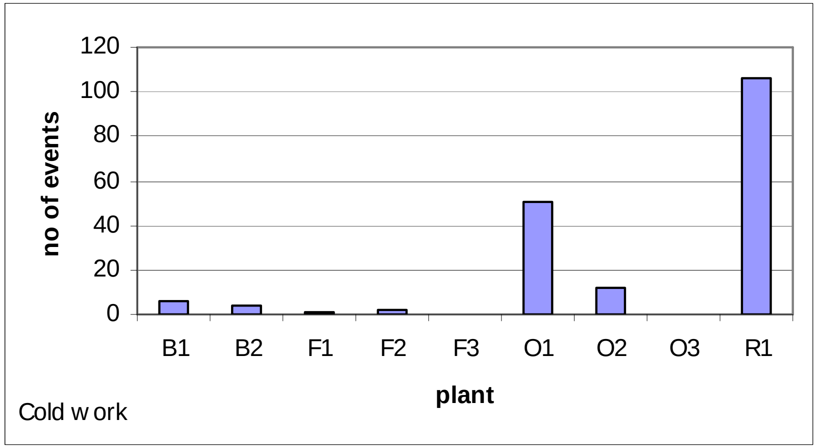
Cold work dominates, unlike e.g. the US where weld sensitisation dominates.

SCC: Sensitisation and Cold Work

Sensitisation: CRD system in R1 dominates. No cases in F3 or O3, built after the problems reported in US.

Circ. cracks in HAZ

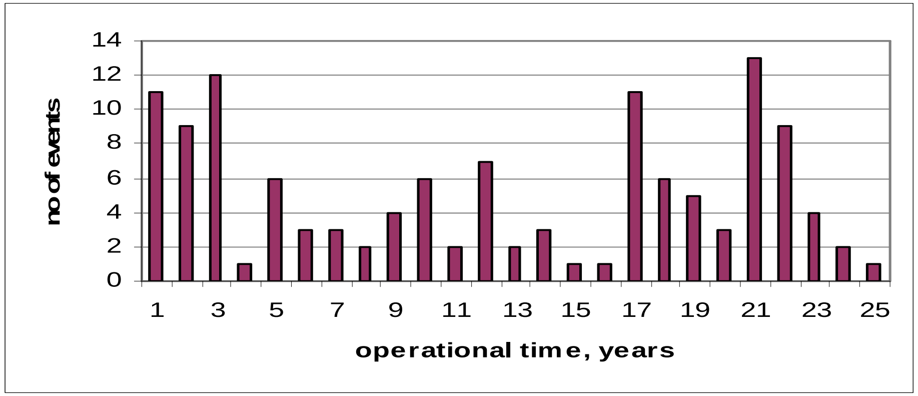




Cold work: Elbows in R1 & O1 dominate. Also grinding or other surface damaging operations, e.g. scratches and punch marks.

Axial, often several cracks, both inner & outer radius of the elbow.

IGSCC per operational year

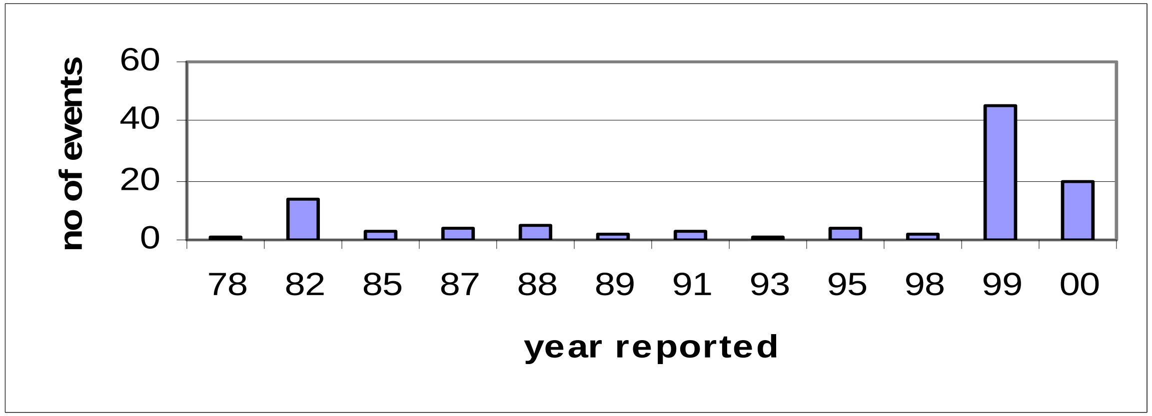


Continuing problem despite replacement of components and HWC

Peaks at about 10 and 21 years due to replacement and inspection after removal

Peak at 17 years due to X-750 events in vessel internals

IGSCC in vessel internals



Example of the effectiveness of inspection techniques

Mostly X-750 with inappropriate heat treatments - cracks found after visual inspection techniques improved for vessel internals.

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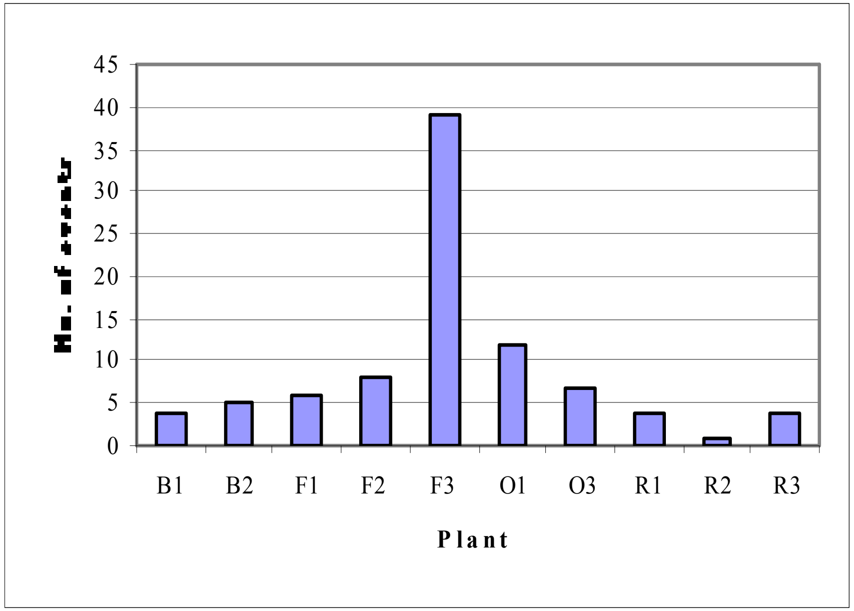
Fatigue in Swedish plants

Concentrated to thinner walled pipes in the reheating and pressure relief systems as well as HP turbine feedwater



Most frequent mechanism for Forsmark 3, but not Oskarshamn 3, an identical plant. No explanation at present

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Concluding remarks

ISI programmes are effective for monitoring the degradation of components for which mitigation measures are inadequate, and for ensuring that unexpected events are caught before component failure.

As such they are an important basis for an ageing management programme, together with a well-planned maintenance programme.

Concluding remarks

A database containing information on the degradation of components and systems is a valuable tool when establishing or reviewing ageing management programmes. It also illustrates the importance of individually designed porgrammes even for nominally identical plants.

Concluding remarks

In order to follow the development of degradation mechanisms and correlate them to inspection programmes it is necessary to include all systems and components in the database, and not limit it to piping.

The OPDE database provides a good basis for participating countries, but is insufficient in its scope since it only contains information on piping events.

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