

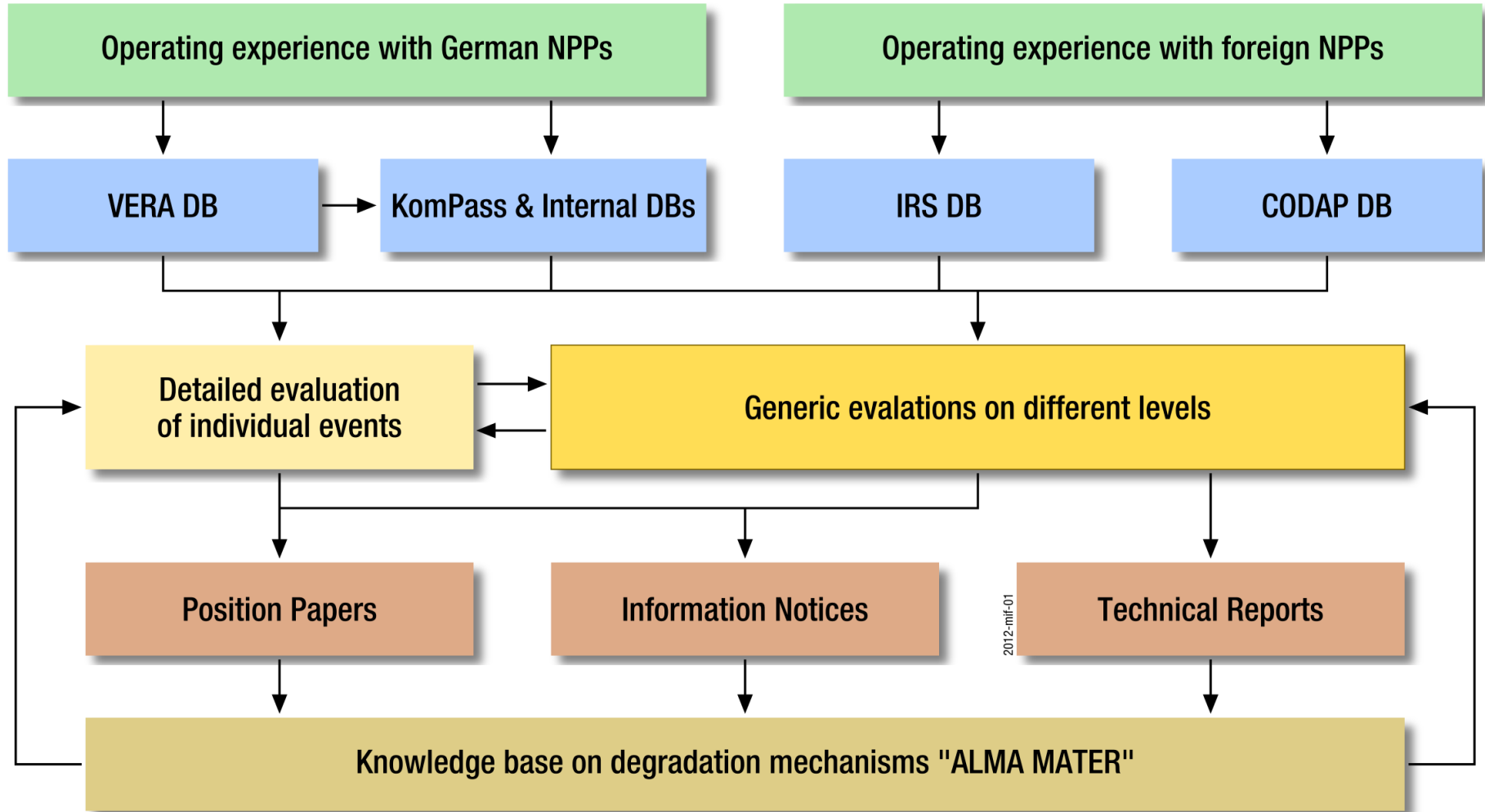
Dr. F. Michel (GRS)

Evaluation of Operating Experience with Regard to Passive Mechanical Components Approach and New Insights

Introduction

- Intention of this presentation
 - to share knowledge gained from 35 years of experience
 - to provide information on the GRS approach
 - to present examples of recent generic studies
- Focus on passive mechanical components (PMCs)
 - pressurised components
 - RPV internals
- A few questions on OE evaluation
 - Where to get the necessary data from and how to store them?
 - How to evaluate the available data?
 - How to make the gained insights retrievable for future work?

GRS approach



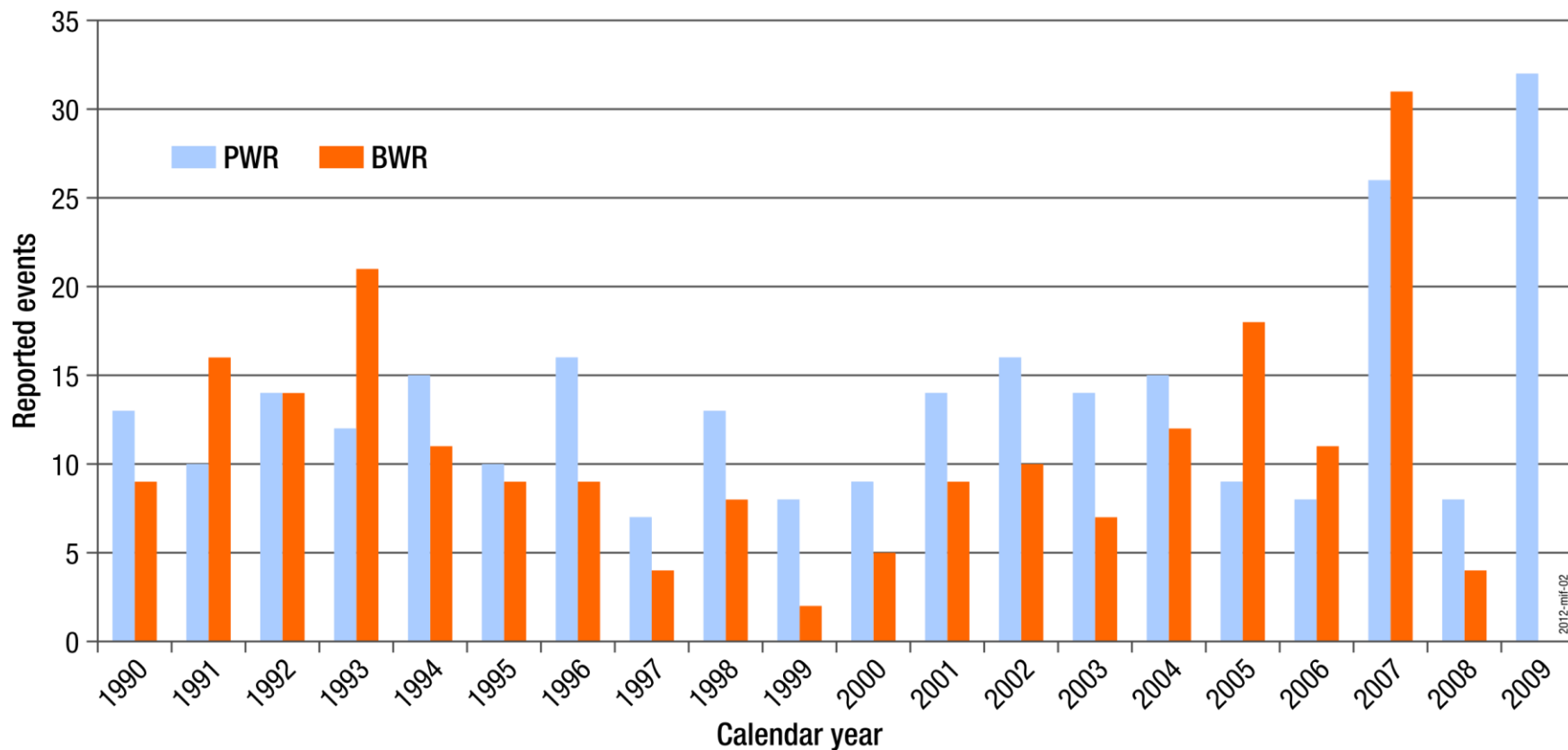
Databases used at GRS for evaluation of OE with PMCs

Database	No. of records	Acquisition period	Scope	Criteria for data capture
VERA	~ 6,000	since 1965	SCCs	Reportable events
KomPass	~ 1,000	since 1972	Pressurised components	Reportable events
Internals	~ 100	since 1973	RPV internals	Reportable events
IRS	~ 3,800	since 1978	SCCs	Selected safety-related events
CODAP	~ 4,500	since 1970	Pressurised components + RPV internals	Selected safety-related events

Examples of recent generic studies performed

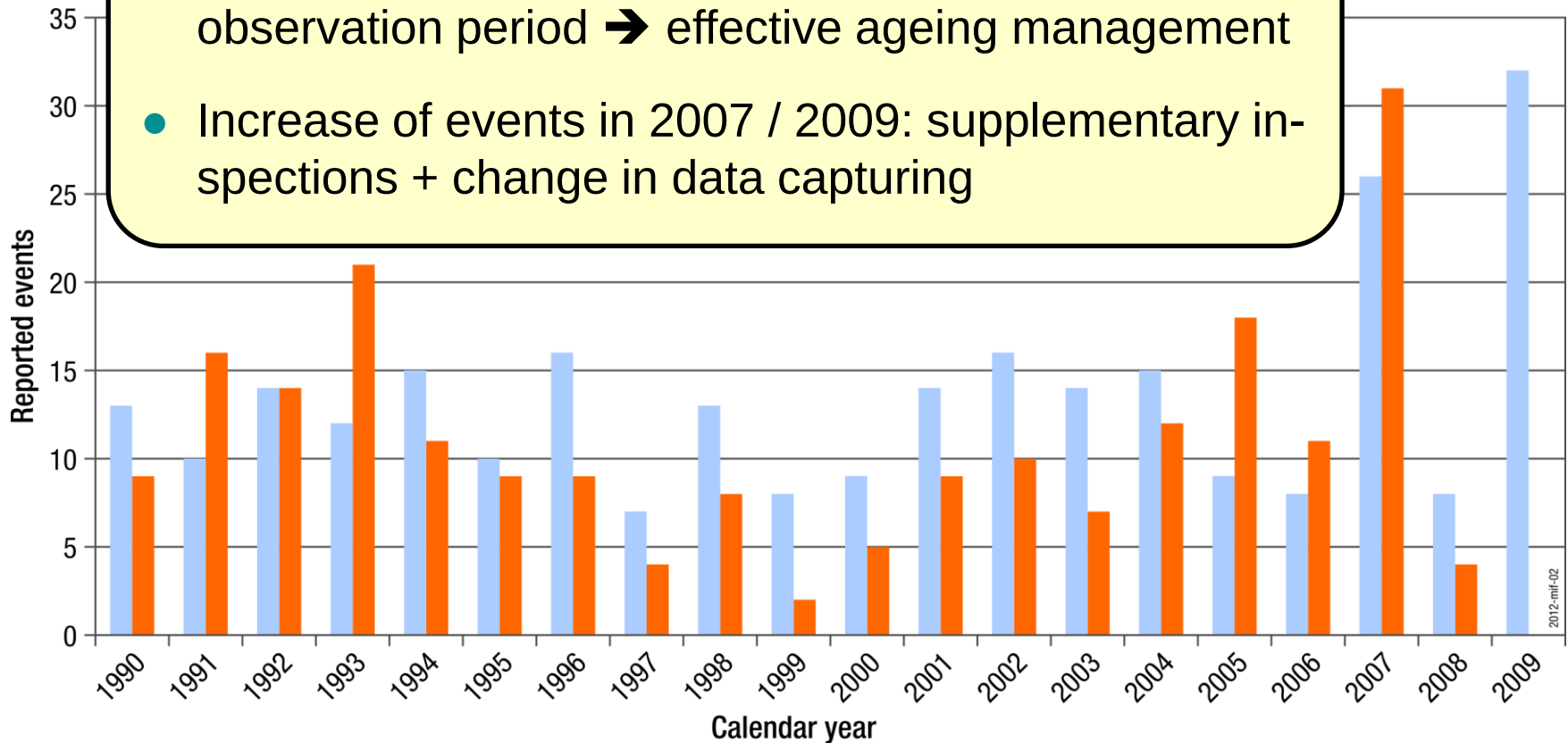
- Ageing behaviour of PMCs
 - topic-specific study on behalf of European CH on OEF
- Environmentally-assisted cracking in PMCs
 - mechanism-specific study on behalf of BMU
- Degradation in essential service water systems
 - system-specific study on behalf of BMU
- Changes in leak frequencies of piping over time
 - topic-specific study on behalf of BMWi

Number of ageing-related individual events in PMCs of German NPPs

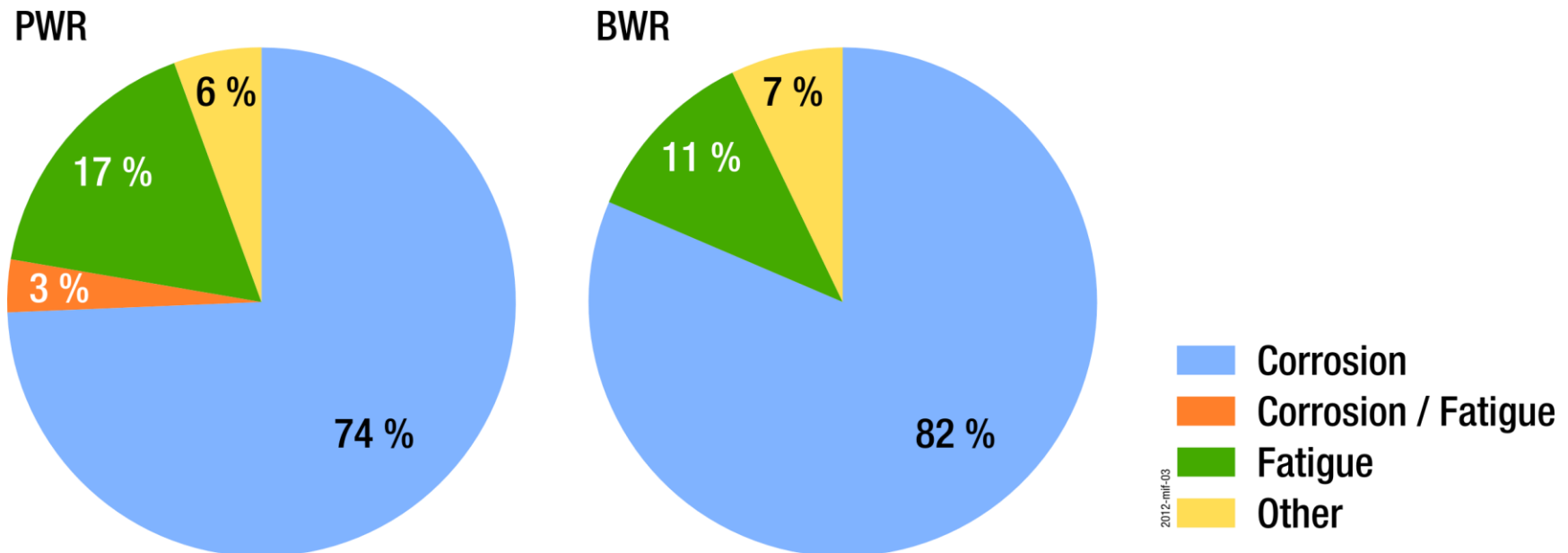


Number of ageing-related individual events in PMCs of German NPPs

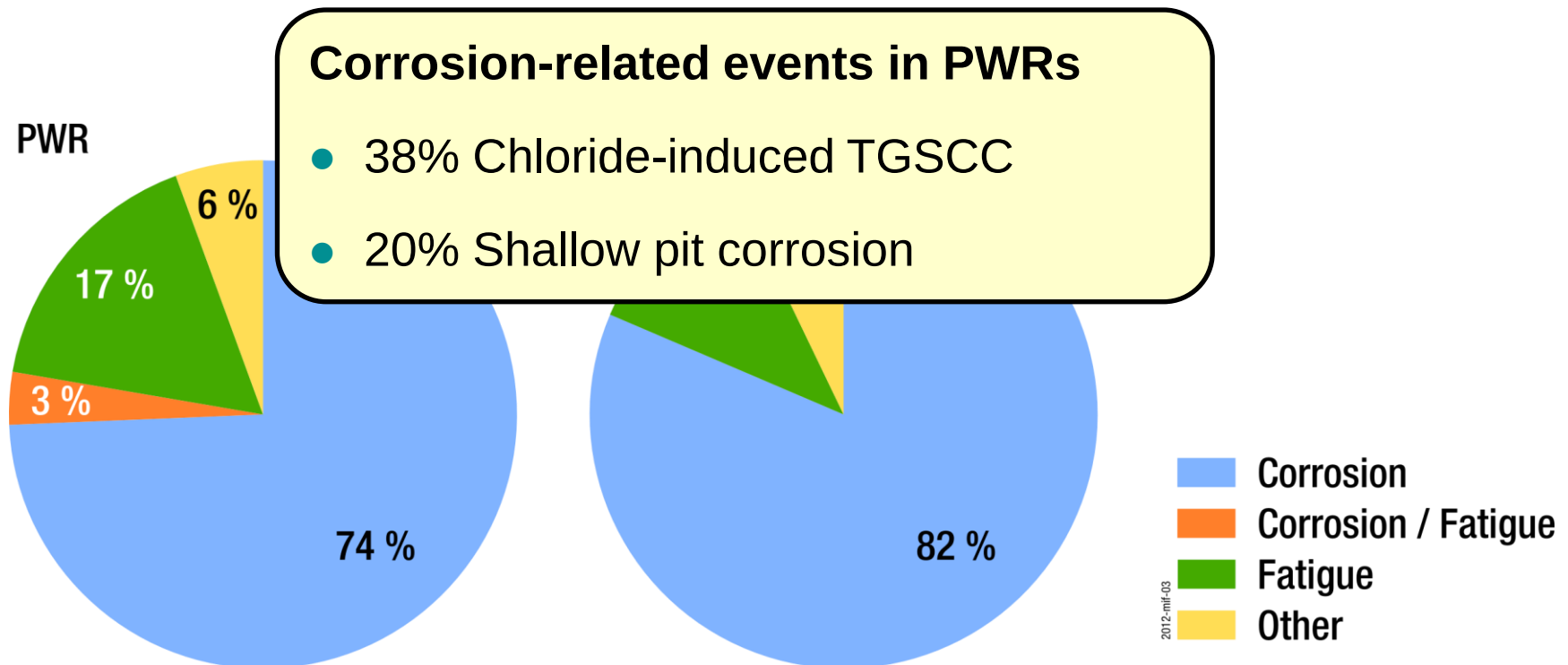
- Number of events remains largely constant over observation period → effective ageing management
- Increase of events in 2007 / 2009: supplementary inspections + change in data capturing



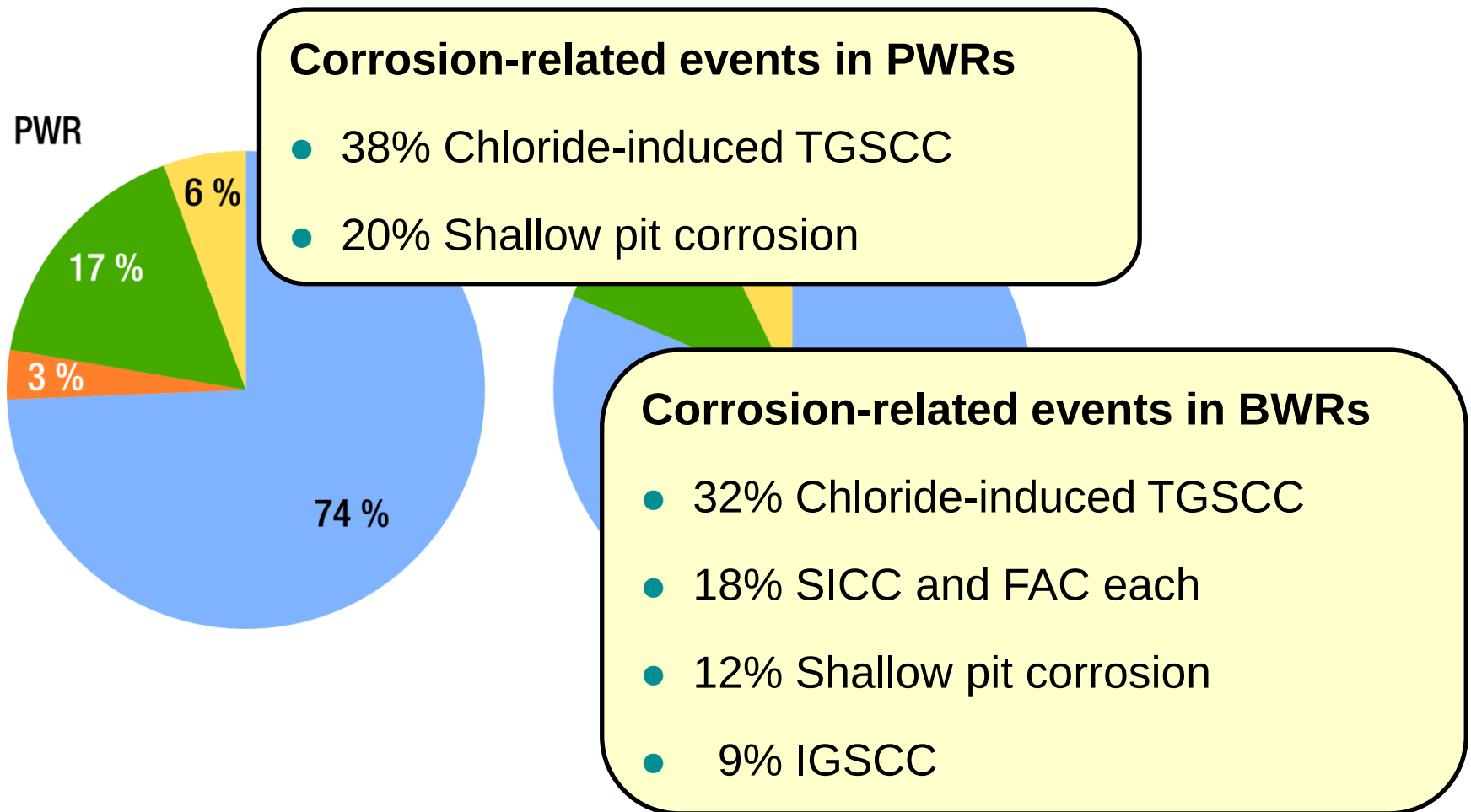
Proportions of degradation mechanisms in PMCs of German NPPs (1990 – 2009)



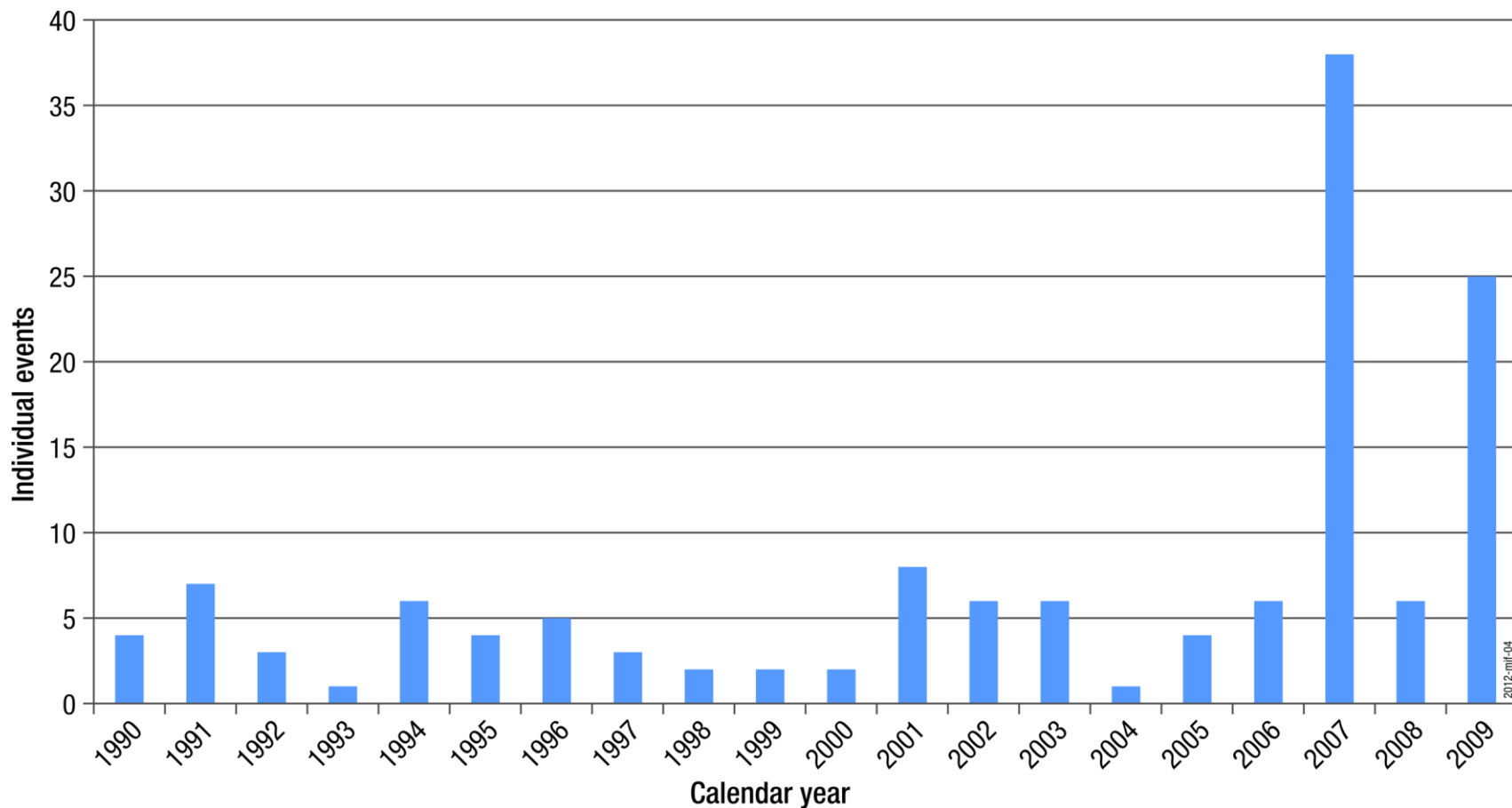
Proportions of degradation mechanisms in PMCs of German NPPs (1990 – 2009)



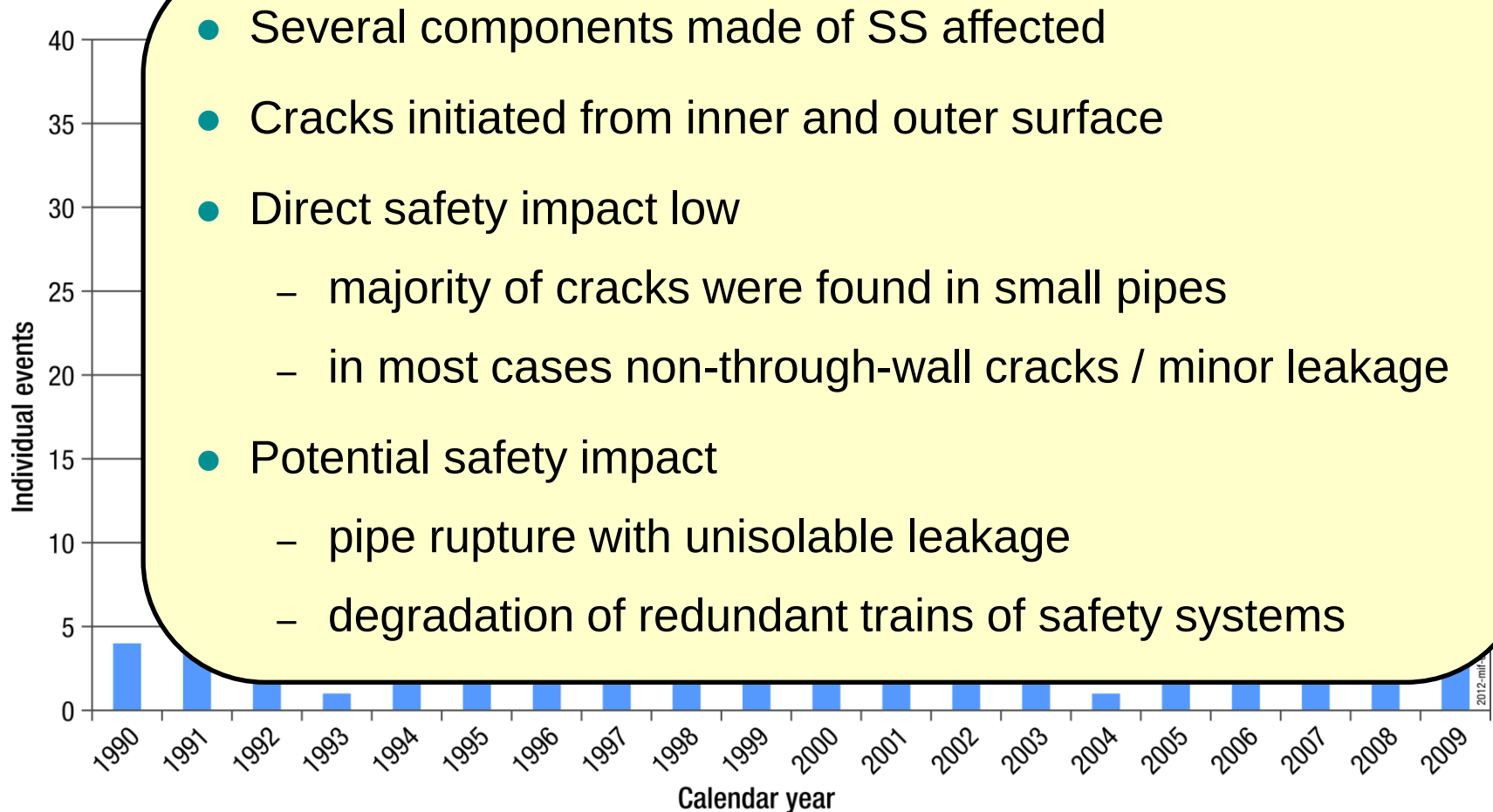
Proportions of degradation mechanisms in PMCs of German NPPs (1990 – 2009)



Number of individual events due to chloride-induced TGSCC in German NPPs by calendar year



Number of individual events due to chloride-induced TGSCC in German NPPs by calendar year



Safety-related events due to chloride-induced TGSCC in German NPPs and events which induced INs

Inner surface

IN 1983/10
Borssele (NL) PWR:
Leakage in a pilot
valve of a pressuriser
safety valve

IN 1982/12
Gösgen (CH) PWR:
Damage in control
lines of the main
steam safety valves

IN 1987/06
BWR-2 (D): Leakage
and cracks in pilot
lines of safety relief
valve (NB 15/25)

BWR-3 (D):
Cracks in head
spray cooling line
(NB 100)*

IN 2001/04
PWR-3 (D): Cracks in the
region of the first isolation
valve of the residual heat
removal system
(NB 240)

IN 2005/14
PWR-4 (D):
Cracks in pipings and valve
bodies of the emergency
feedwater system

IN 2008/03
BWR-3 (D):
Cracks in austenitic
valve bodies



BWR-1 (D):
Leakage in a
control line
(NB 15)*

PWR-1 (D):
Leakage in a
pressurizer
sample line
(NB 15)*

PWR-1 (D):
Cracks in a HP
injection line
(NB 125)

BWR-4 (D):
Cracks in an
exhaust steam line
of the HP coolant
injection turbine
(NB 700)

PWR-2 (D):
Leakage and cracks in
several instrument lines
(NB 15/25)*

BWR-1 (D):
Leakage in a
leak-off line
(NB 25)*

IN 2009/02
Cofrentes (E) BWR:
Leakage in control rod
drive mechanisms
piping

Outer surface

IN 1998/01

*unisolable

Safety-related events due to chloride-induced TGSCC in German NPPs and events which induced INs

Inner surface

IN 1983/10

Borssele (NL)

Leakage

valve

sa

IN 1987/06

IN 2005/14

- Avoid any contact of chlorides with components made of SS
 - identify any chloride sources
 - identify areas where accumulation of chlorides may occur
- Measures taken in German plants
 - specification of adhesives, gaskets, lubricants, etc.
 - supplementary inspections + enhancement of ISI programmes
 - repair or replacement of components with cracks
- Is chloride-induced TGSCC from inner surface a specific issue in German NPPs only and, if so, why?

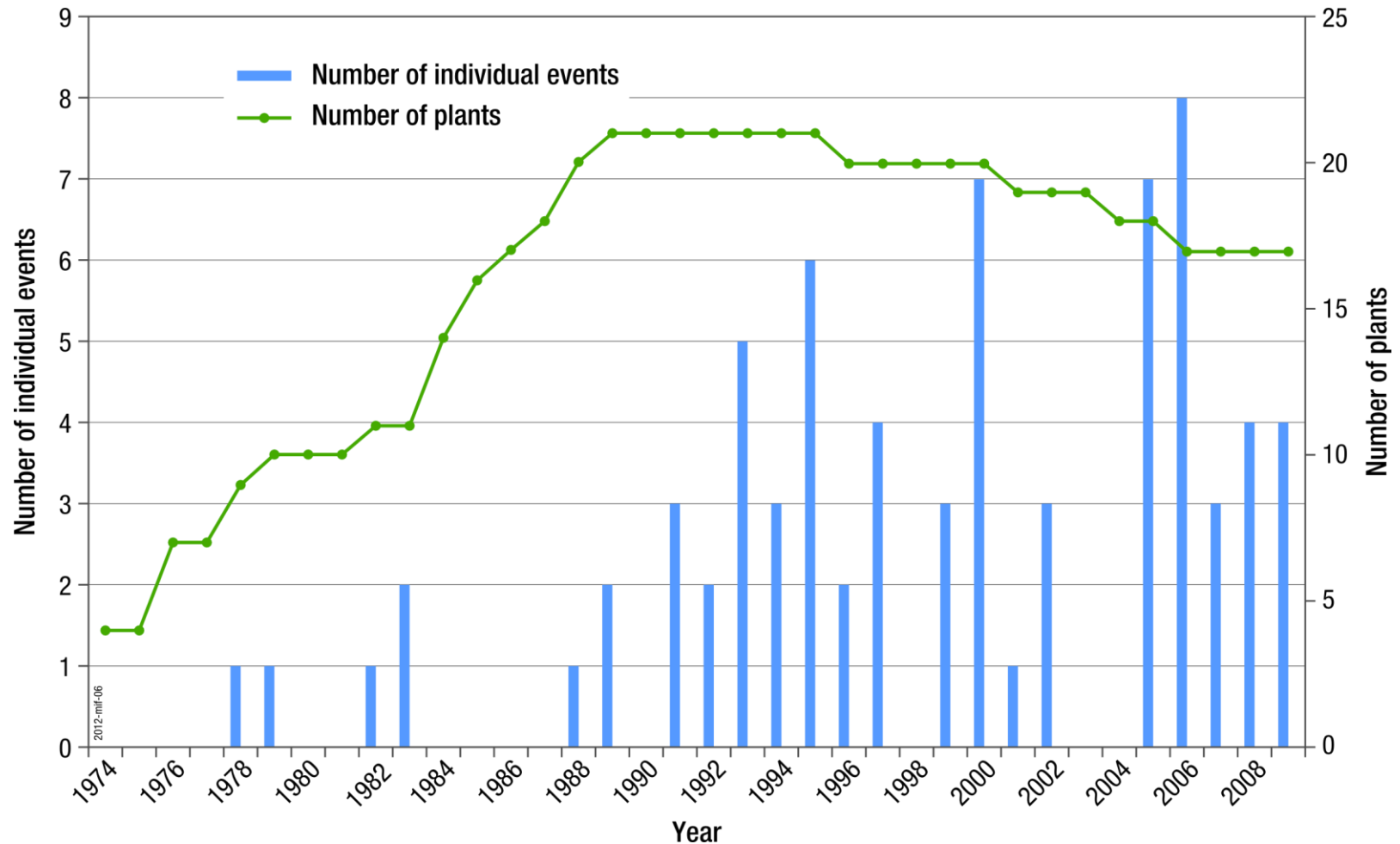
IN 1983/10
Gösg
Dam
lines
stea

nitic

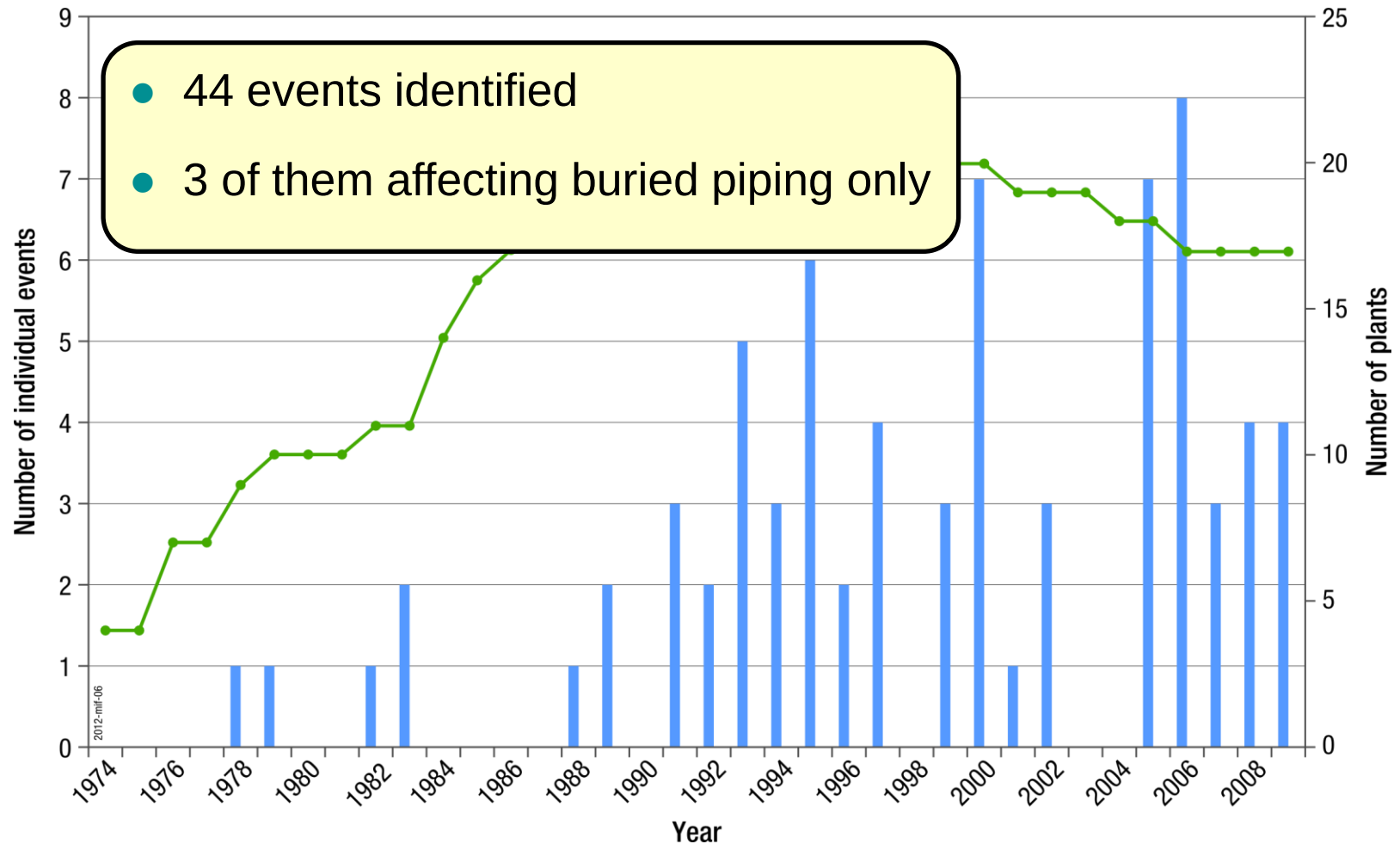
Outer

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Events due to degradation of piping in essential service water systems of German NPPs (1974-2009)

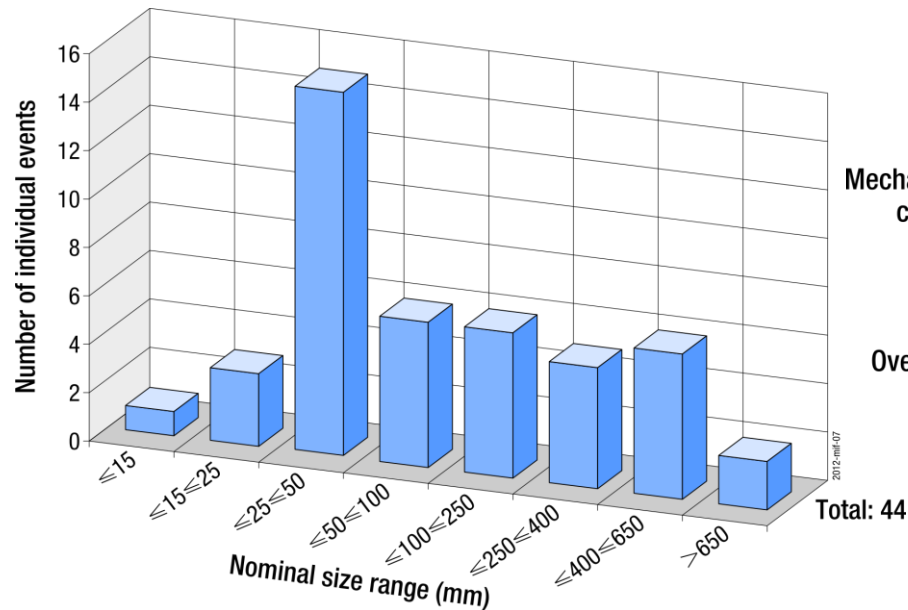


Events due to degradation of piping in essential service water systems of German NPPs (1974-2009)

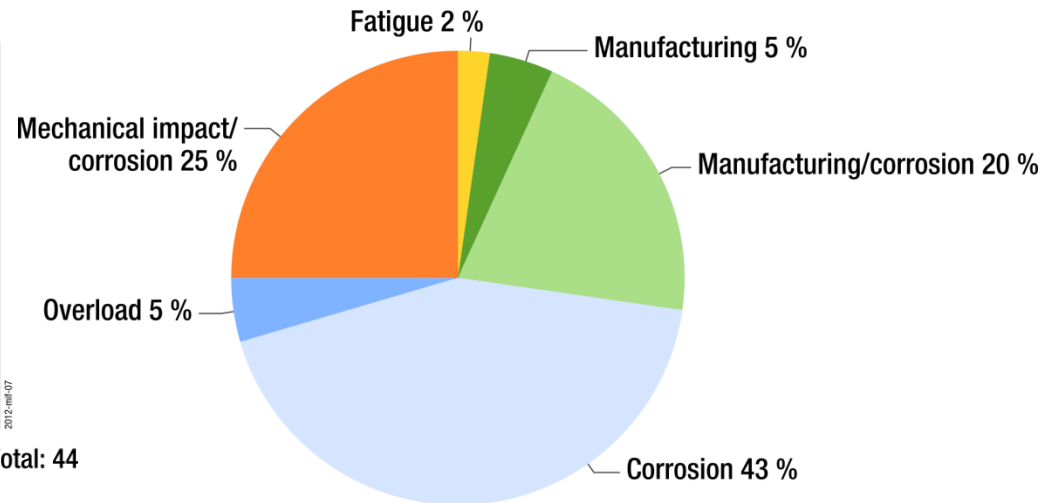


Events in piping of essential service water systems of German NPPs (1997-2009)

by nominal size ranges

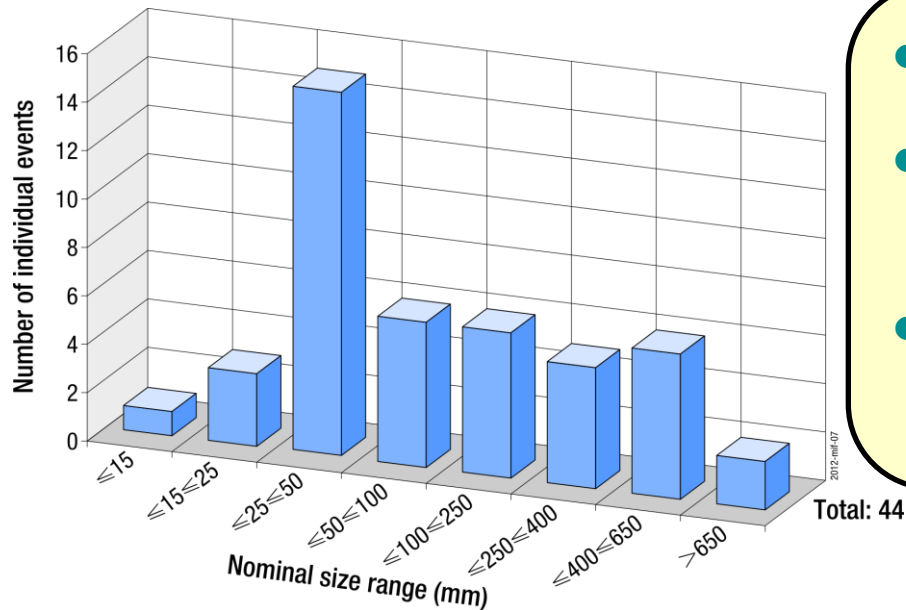


by degradation mechanisms



Events in piping of essential service water systems of German NPPs (1997-2009)

by nominal size ranges

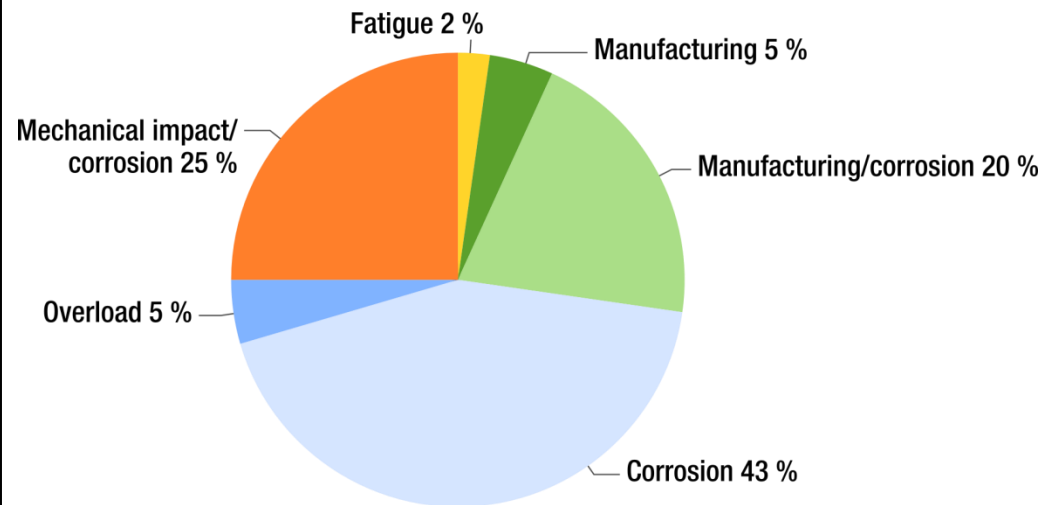


- Piping of all ranges affected
- Events in piping of NB ≥ 400 mm only reported from older plants
- Majority identified by walk-downs, in large piping within ISI

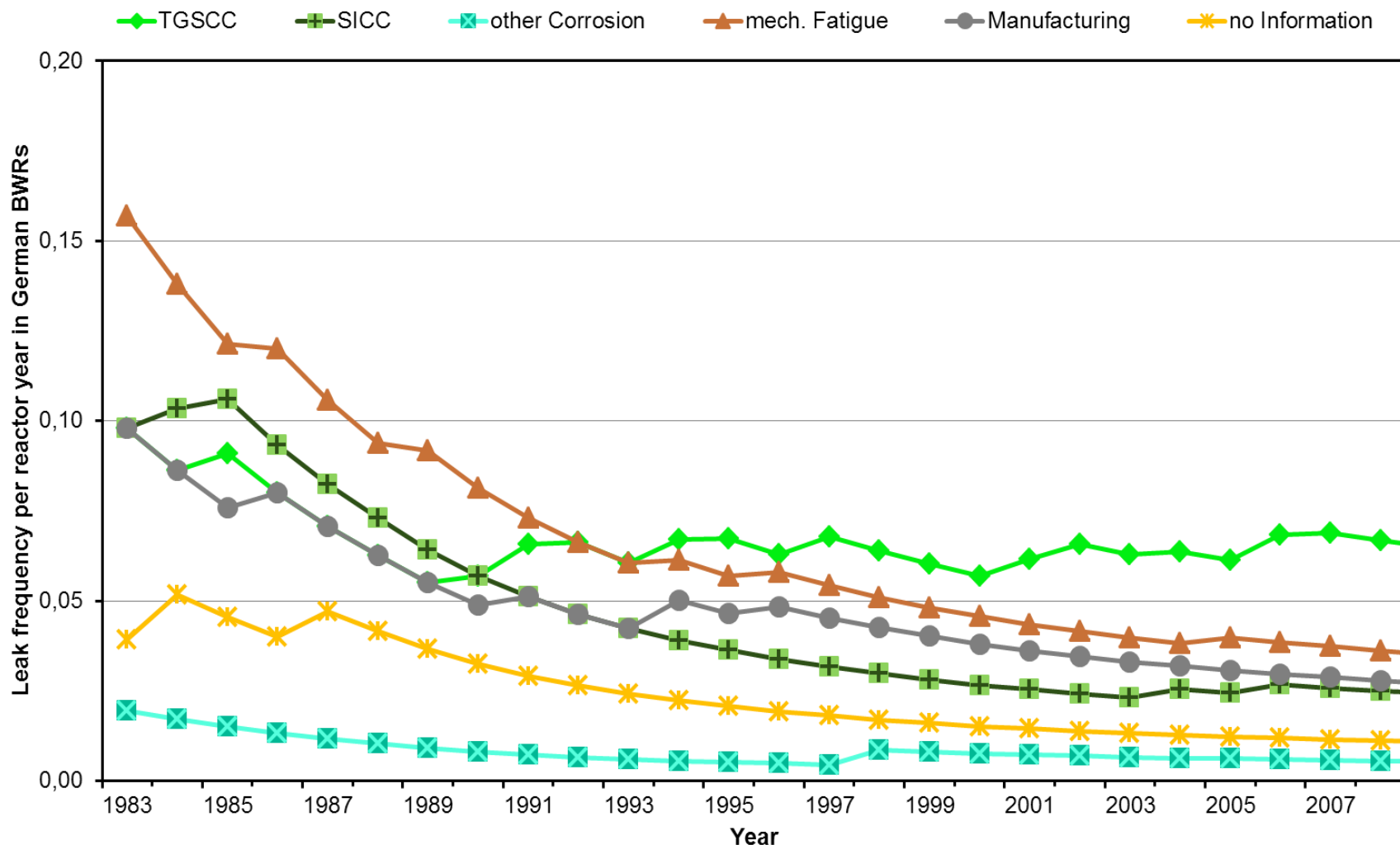
Events in piping of essential service water systems of German NPPs (1997-2009)

- Through-wall shallow pits in piping made of LAS
- Coating failure due to
 - manufacturing defects
 - mechanical impact
- Areas with stagnant / turbulent flow conditions
- New insights from OEF have been considered in KTA 3211.4 (ISI schedule)

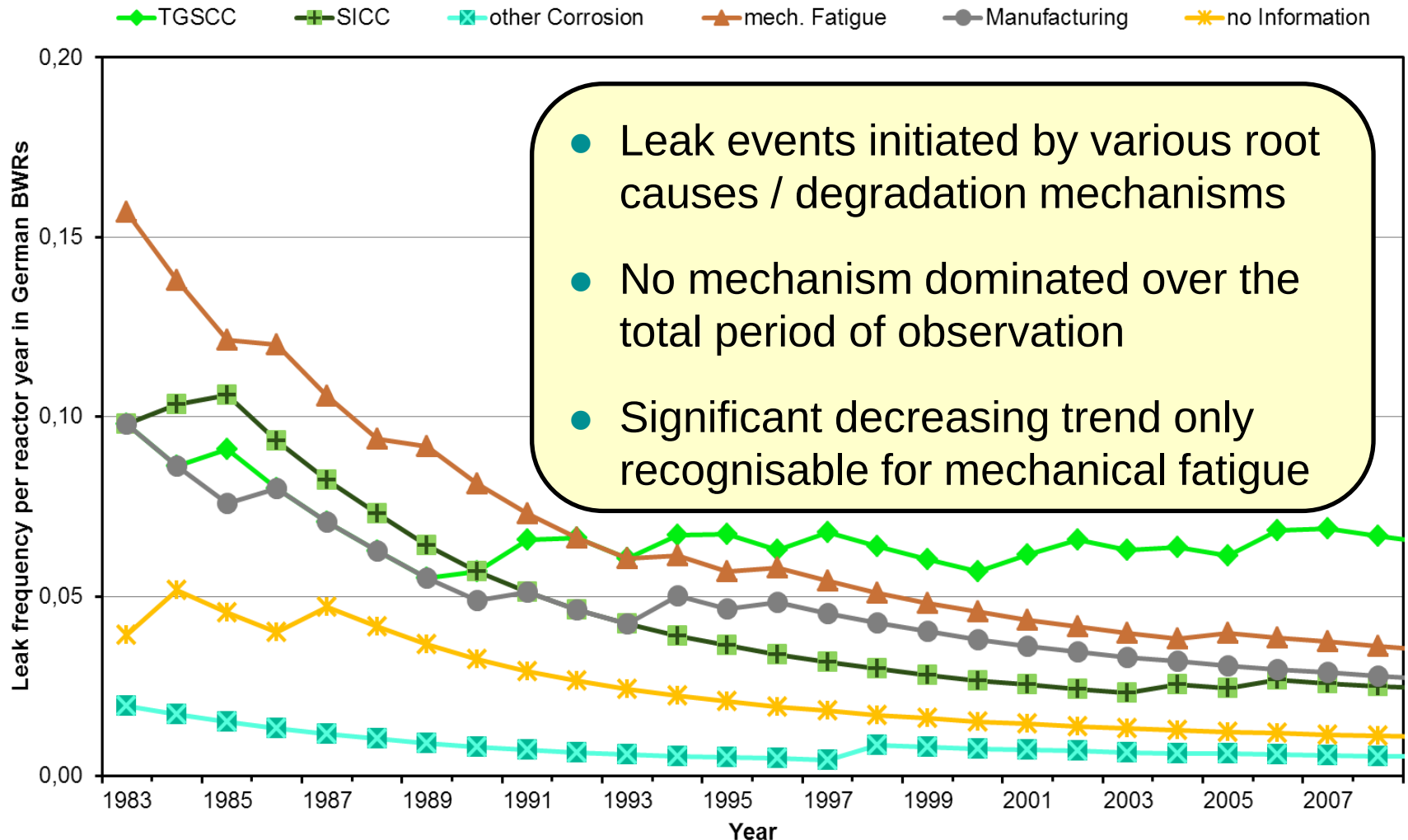
by degradation mechanisms



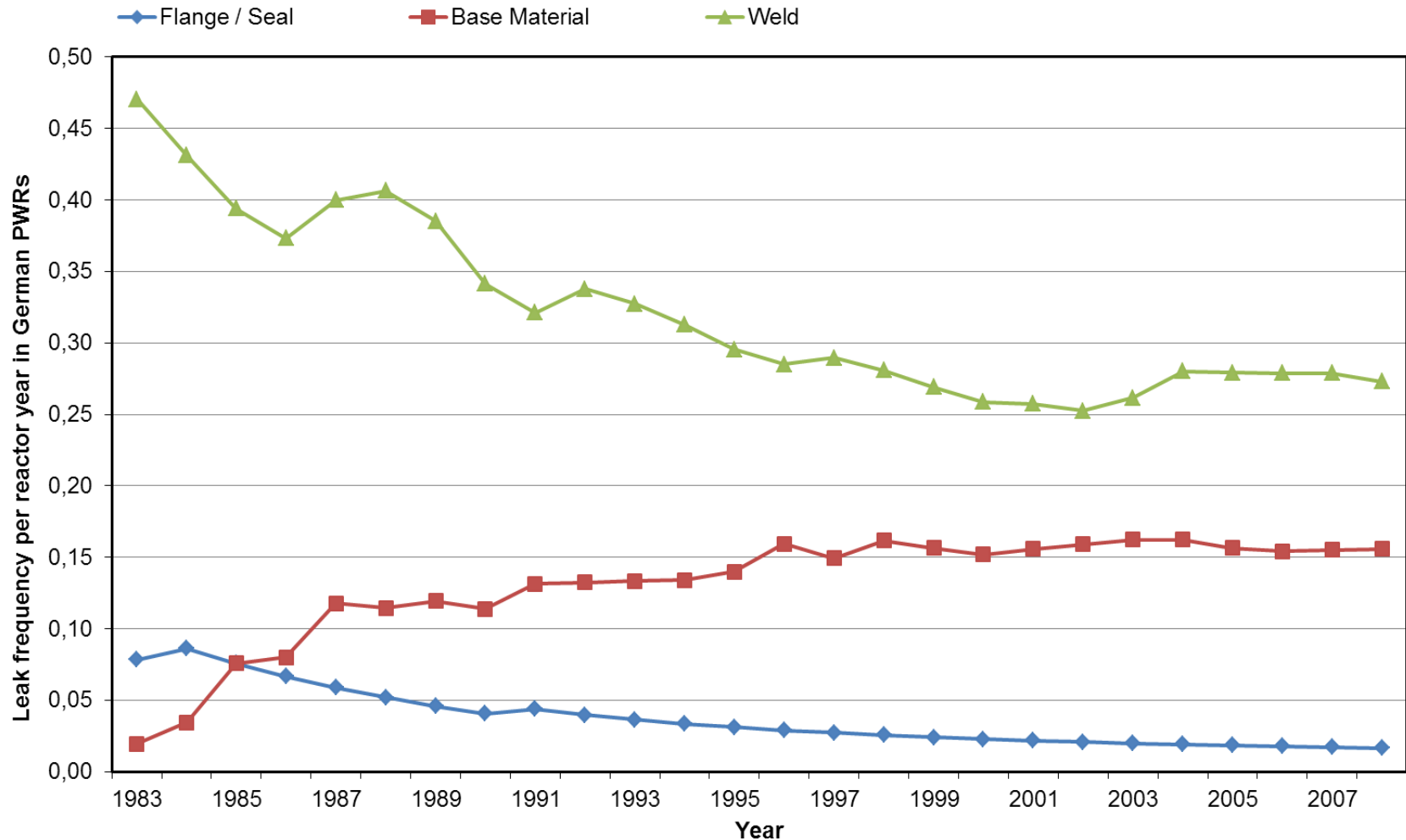
Leak frequencies of safety-related piping in German BWRs depending on the root cause by calendar year



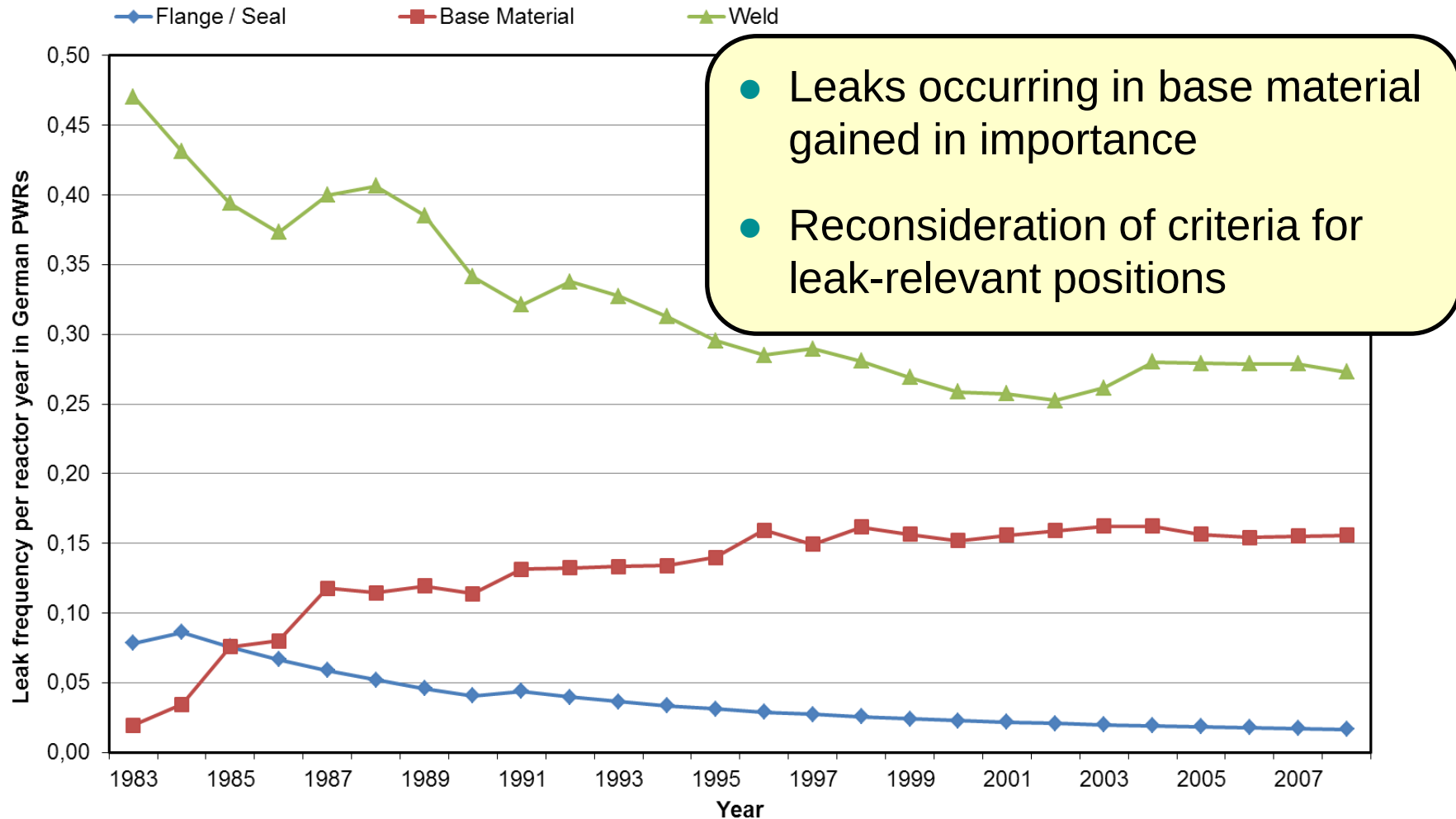
Leak frequencies of safety-related piping in German BWRs depending on the root cause by calendar year



Leak frequencies of safety-related piping in German plants with PWR depending on location of damage



Leak frequencies of safety-related piping in German plants with PWR depending on location of damage



Conclusions

- GRS is evaluating OE in order to early identify changes in the reliability of PMCs and corresponding safety issues
- GRS has established appropriate data and knowledge bases as well as tools and methods for this
- For German NPPs, results confirm robustness of component design and effectiveness of measures taken, such as
 - extended plant monitoring
 - optimisation of operating conditions
 - enhancement of ISI programmes and NDE techniques
 - replacement of components sensitive to degradation
 - enforcing technical requirements in codes and standards
 - implementation of target-oriented R&D programmes

Outlook

- Future GRS work on OE evaluation with PMCs will comprise in particular
 - maintaining, updating and extending of available data and knowledge bases
 - further evaluation of available data in a specific way
 - co-operation in international WGs in order to ensure that sufficient information for safety assessment is available
- Generic studies under way / in the pipeline at GRS
 - long-term behaviour of RPV internals (on behalf of BMU)
 - cracks and leaks of the RCPB (CH on OEF)
 - FAC in water-steam cycles (OECD CODAP)