

# HV XLPE CABLES

**STATE OF THE ART  
DESIGN / MANUFACTURE ISSUES**

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# Content

- State of the art
  - Stress / thickness
  - Service performance
  - Downsizing
  
- Design
  - Temperature
  - Strength
  - Length
  - Ageing
  
- Manufacture
  - Degassing
  - Scorch

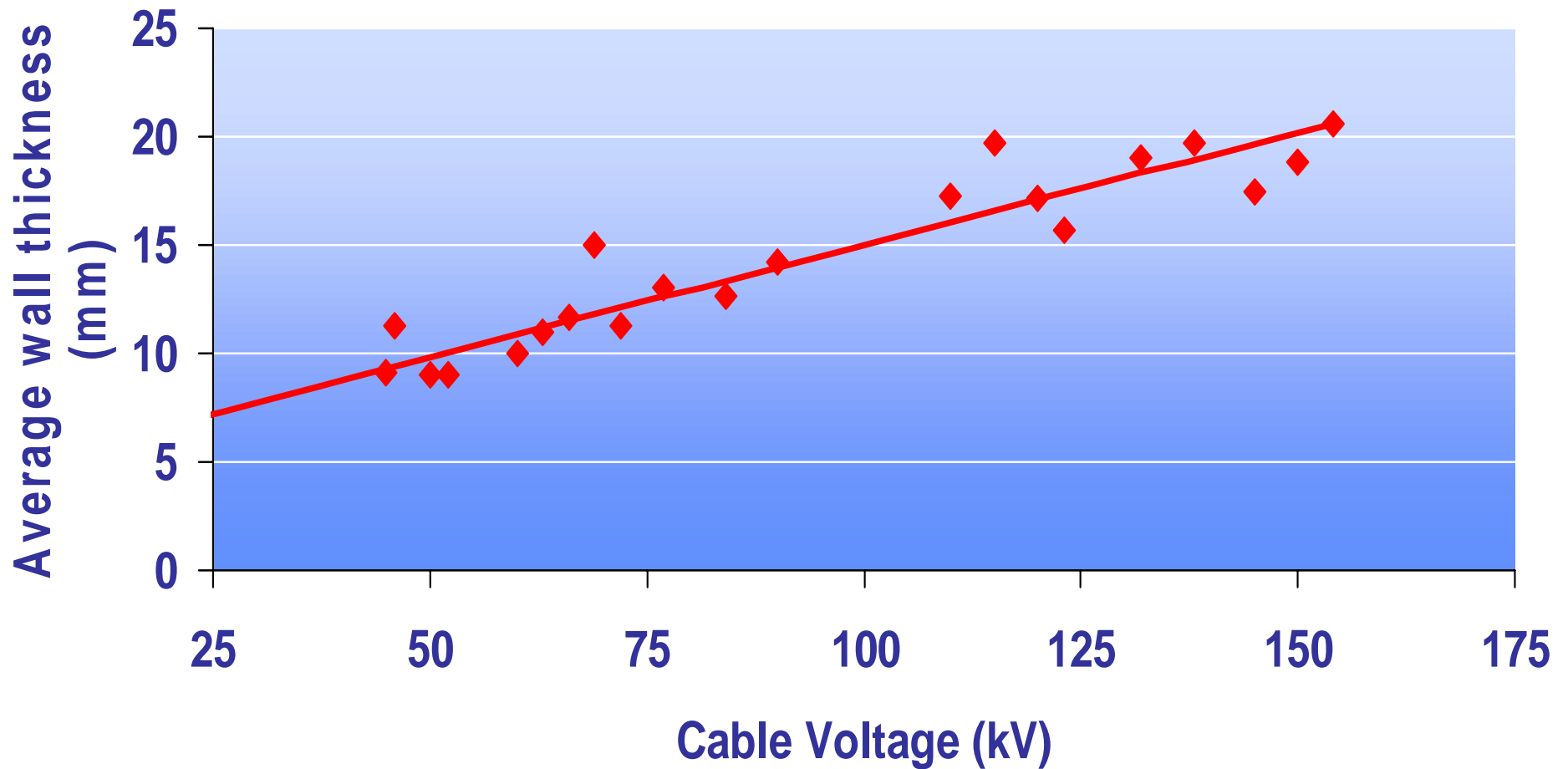
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## Content

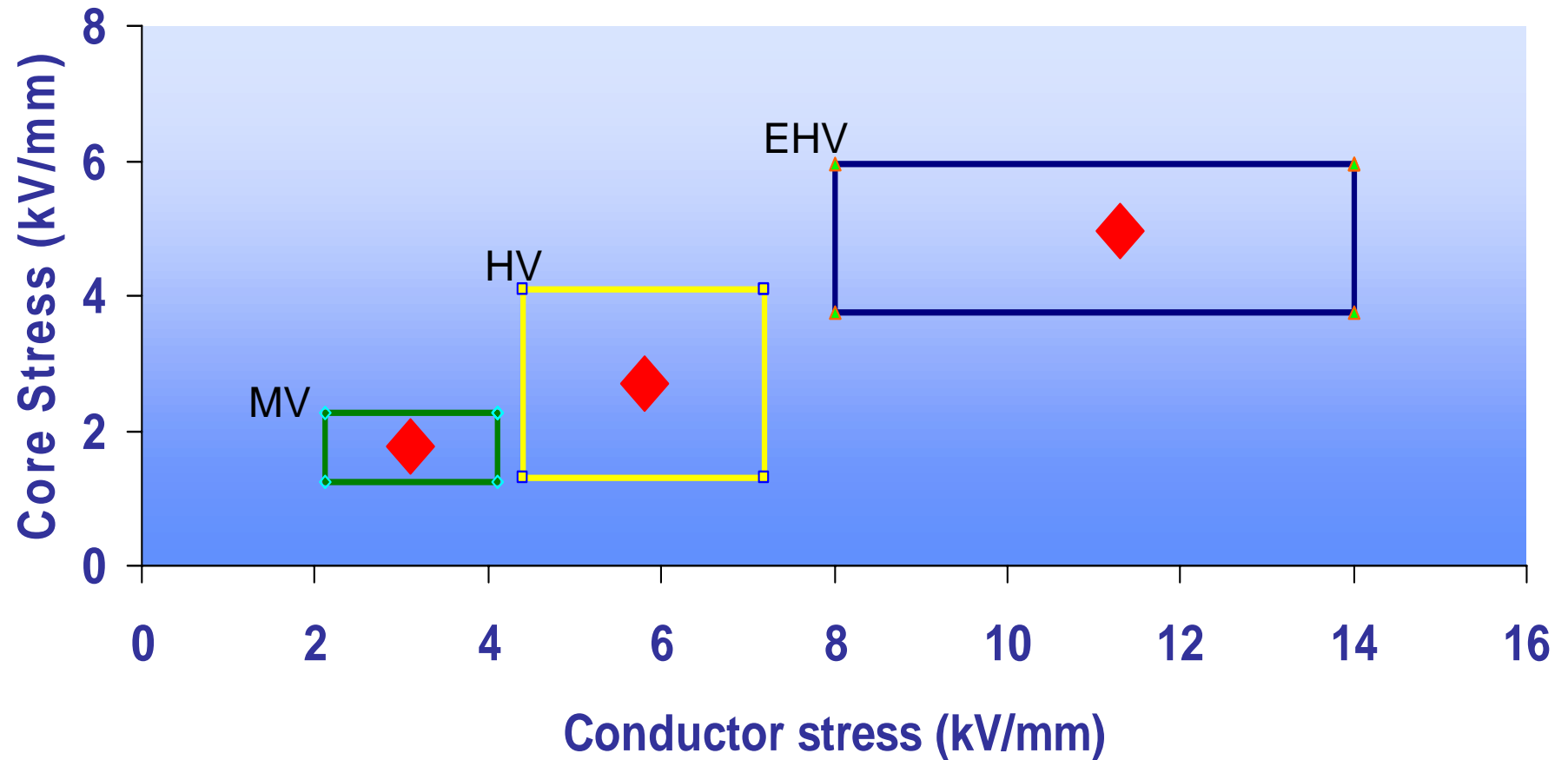
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  - Purity**

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## Thicknesses of Insulation for HV Cables



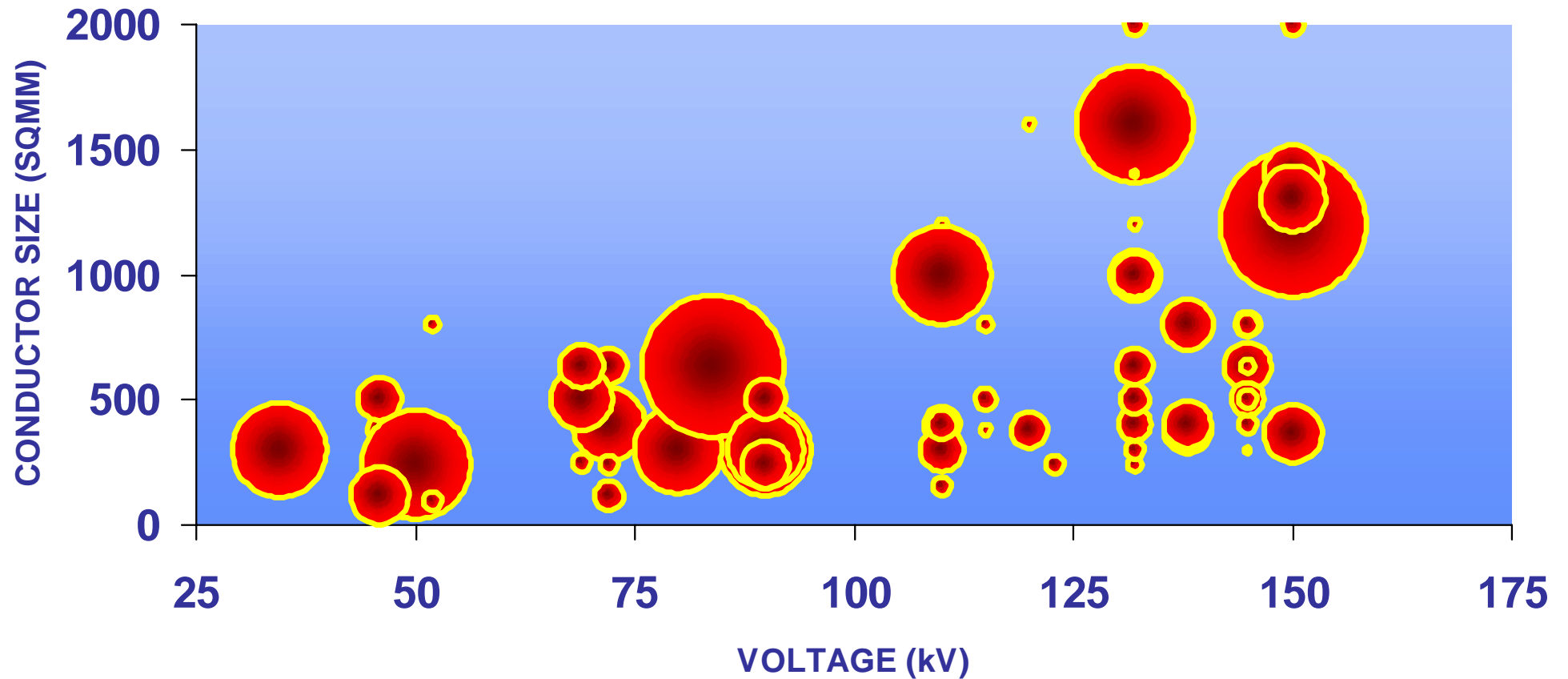
# Electrical Stresses



Mean & 90% Conf Limits

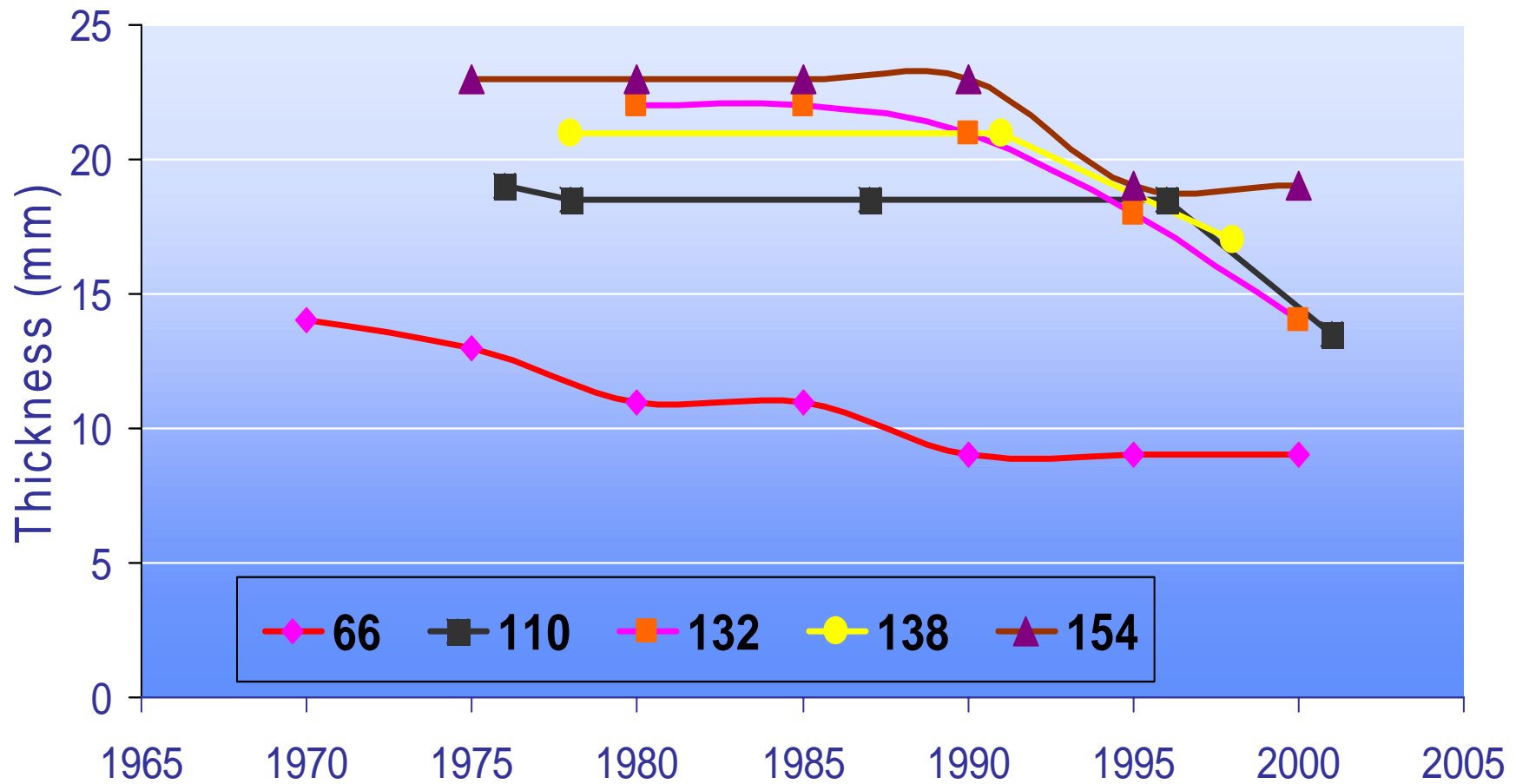
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## Selected HV Experience

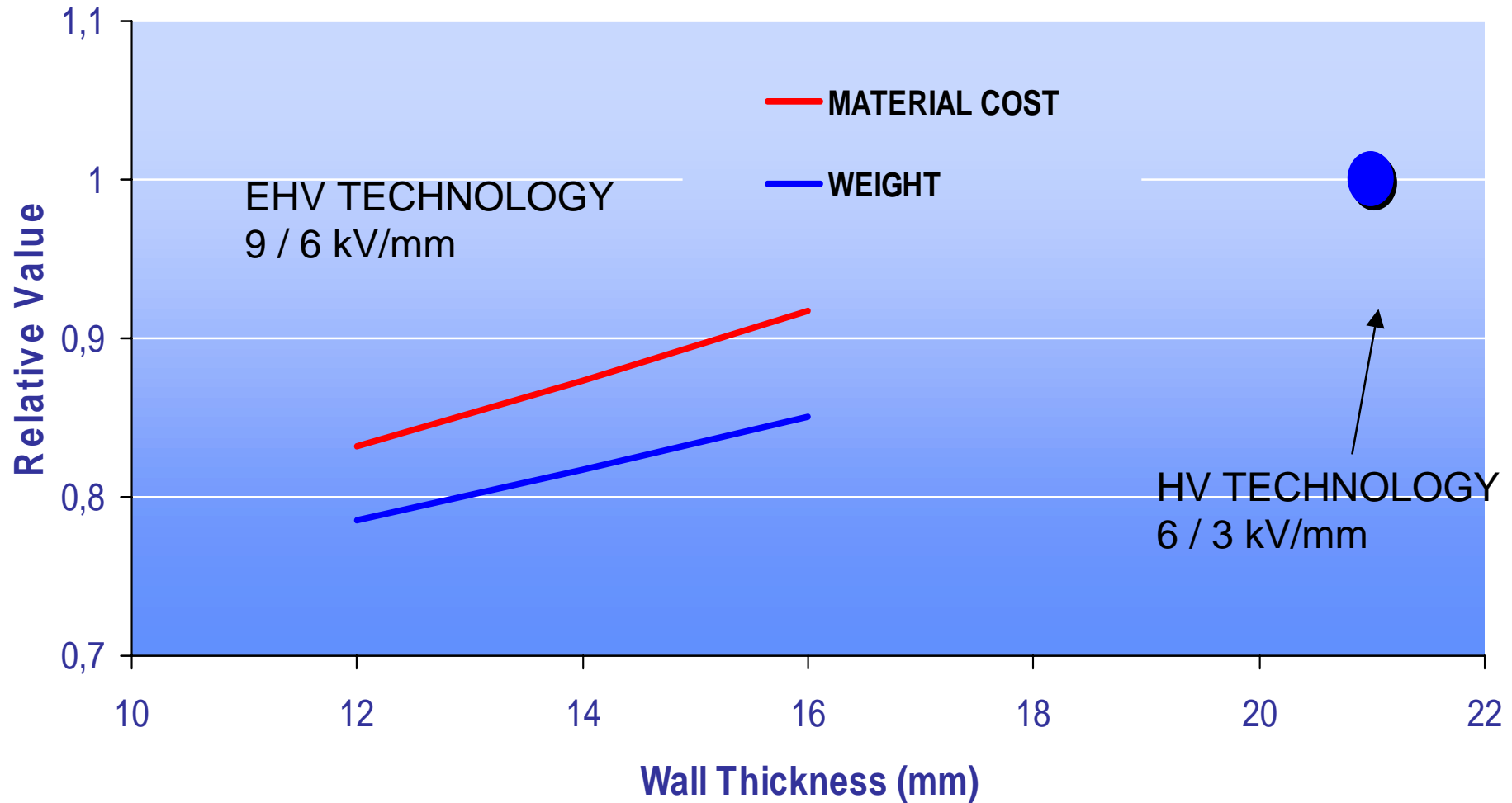


Size Of Bubble Represents Length Of Installed Cores

## Thicknesses of Transmission Cables



## Use of EHV Technology to Down Size

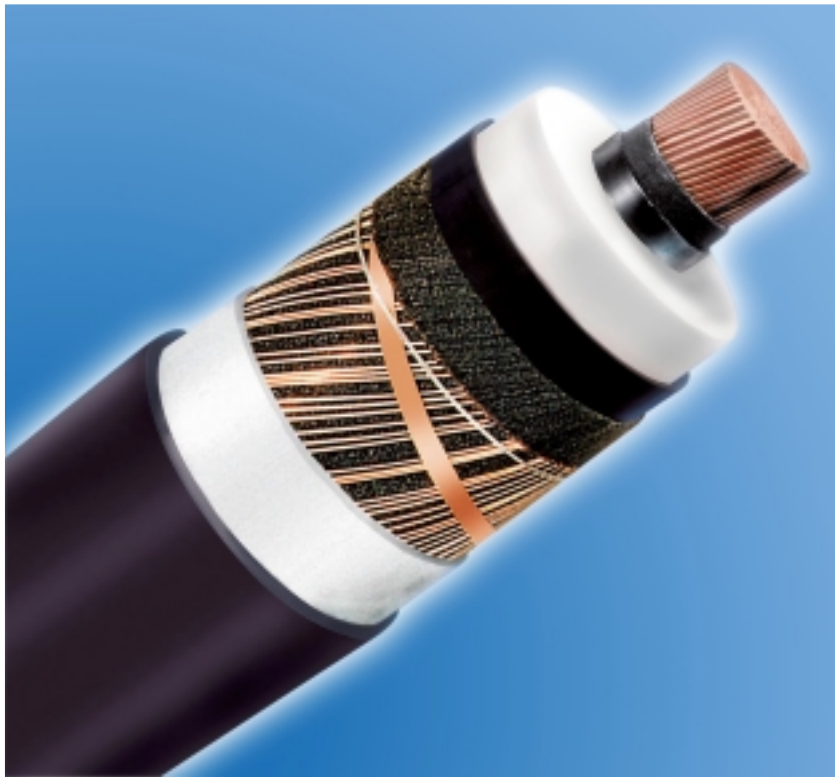


1000SQMM, Pb SHEATH



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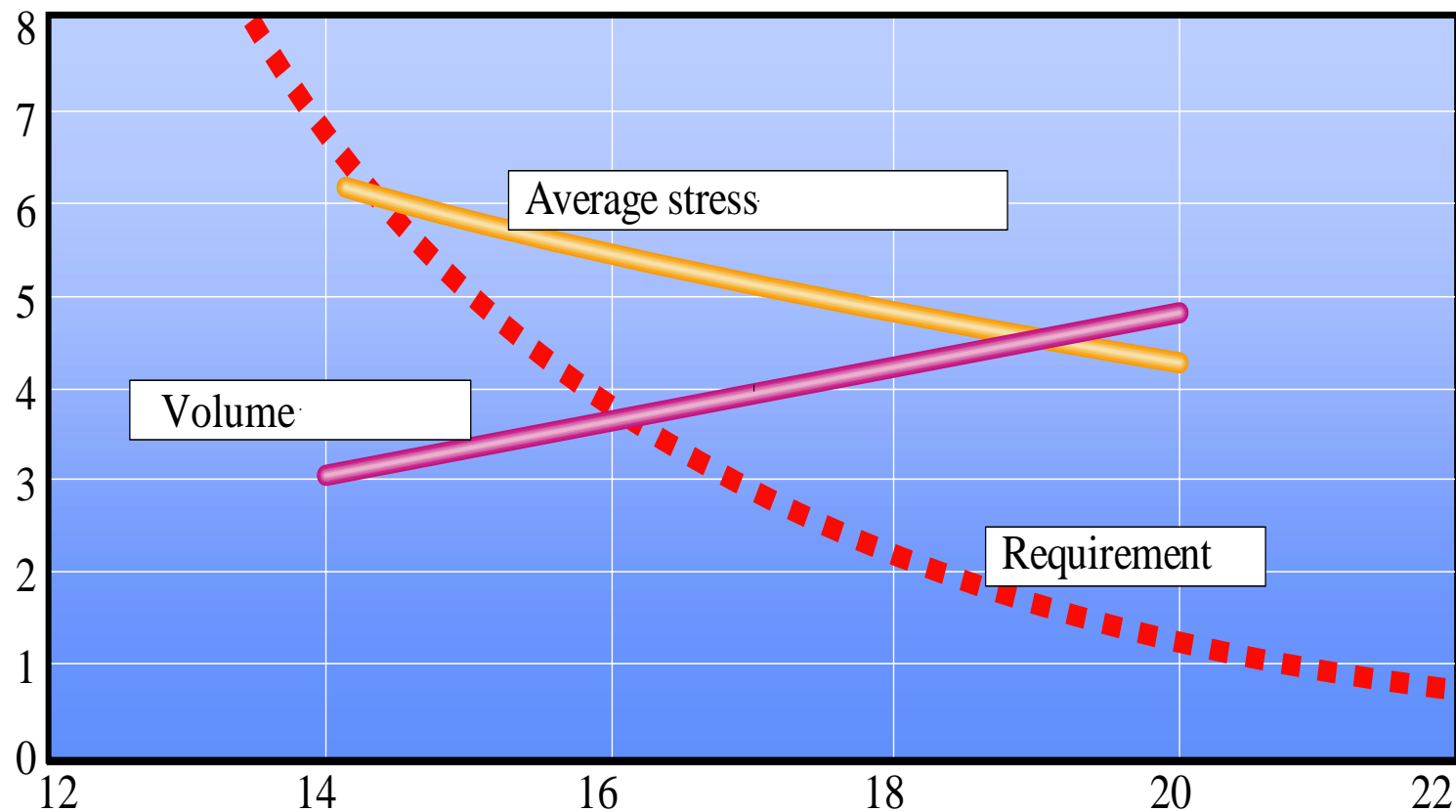
## High Stress Gives Smaller Cables



>15% reduction in weight

5 - 10% reduction in material cost

## Size Affects Electrical Requirement



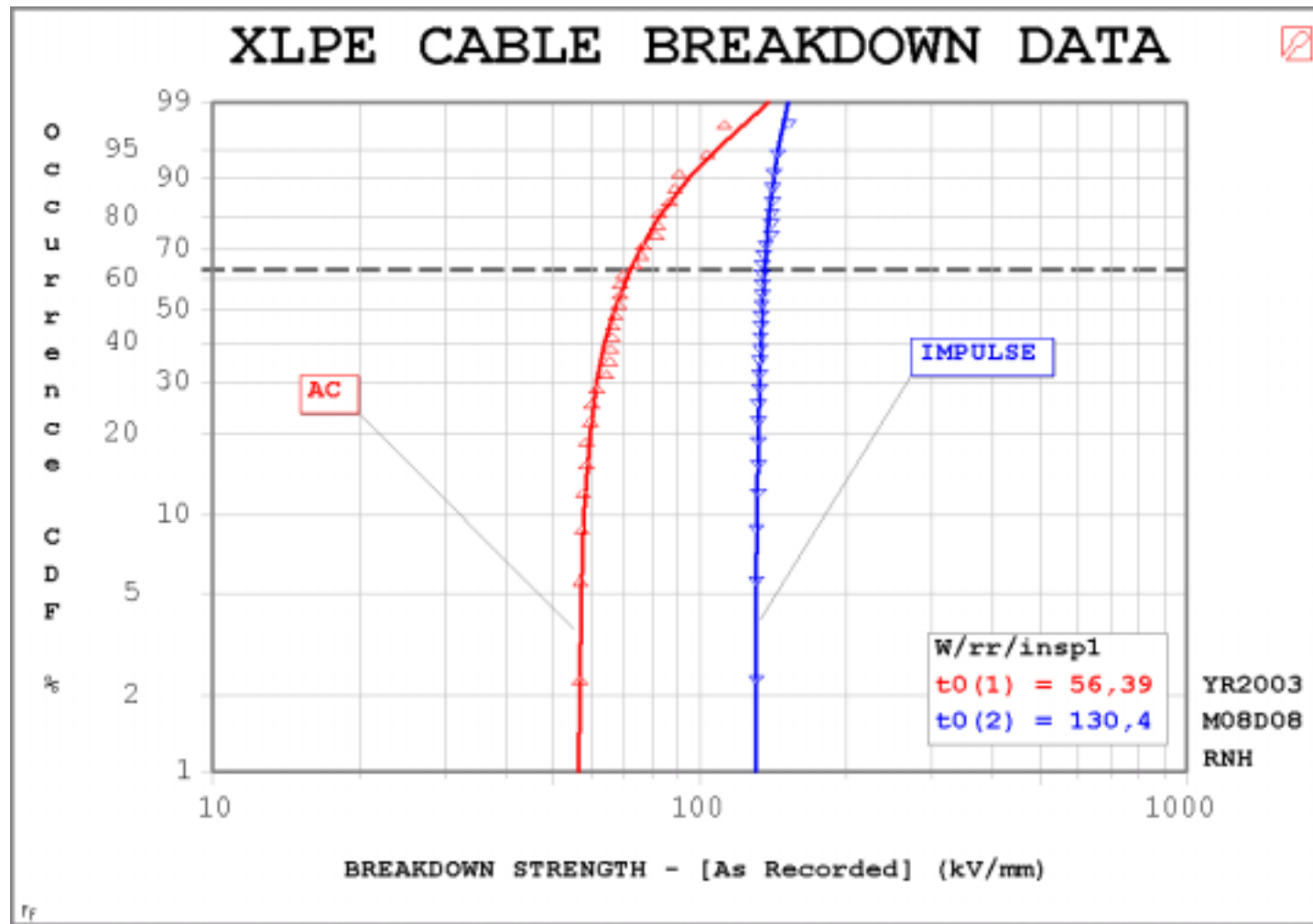
Reference case - 2000mm<sup>2</sup> 150kV

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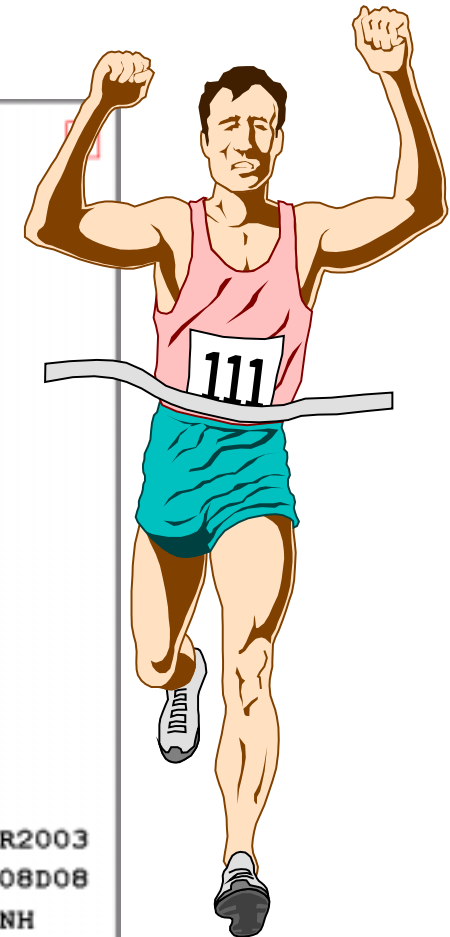
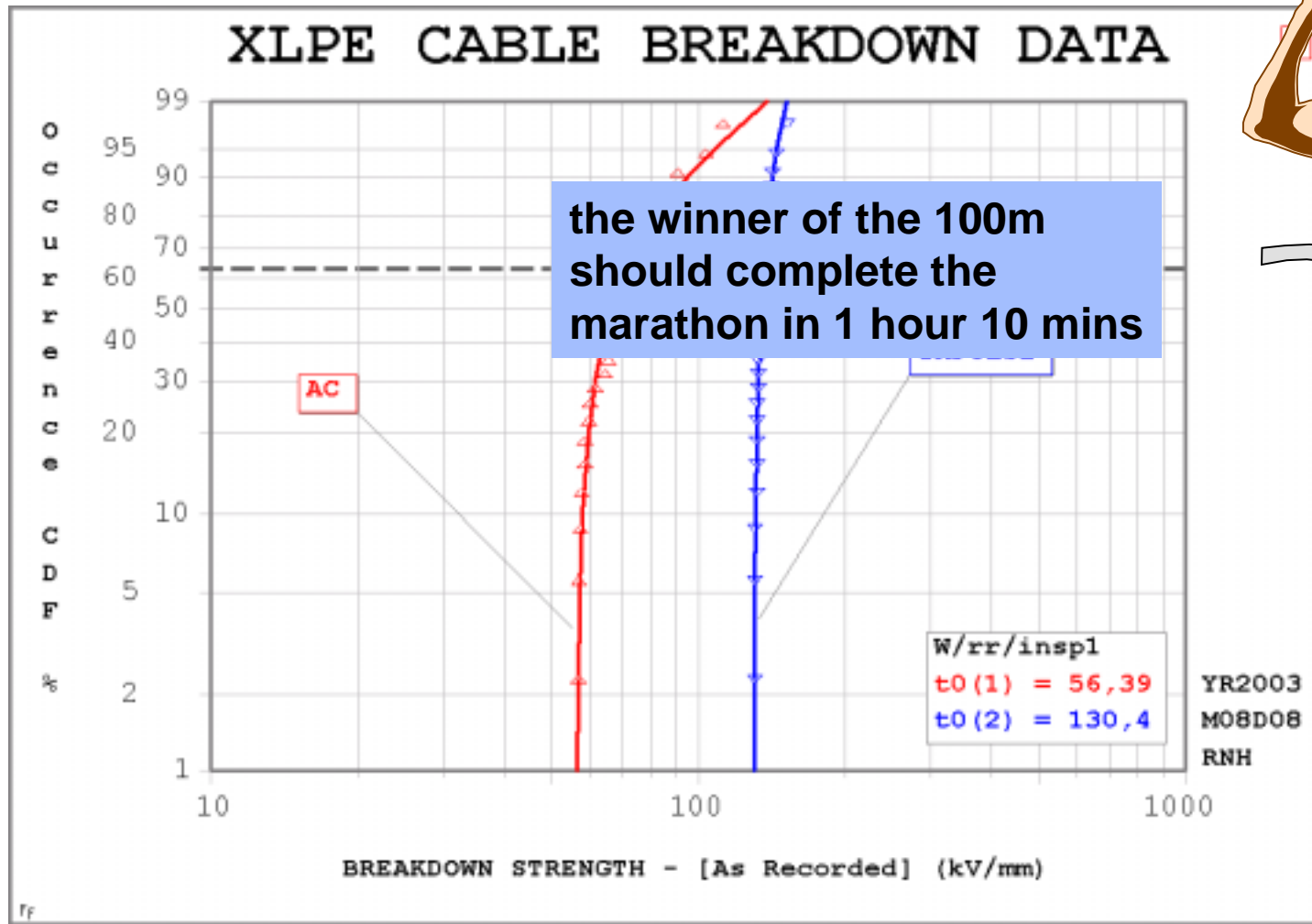
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# Breakdown Stress - Design Stress



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## Designing Cables

- Design Life
- Size
- Temperature
- Safety

$$E_{\text{design}} = \frac{E_{\text{breakdown}}}{F_{\text{age}} F_{\text{size}} F_{\text{temp}} F_{\text{safety}}}$$

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## What Is The Outcome?

$$E_{\text{design}} = \frac{E_{\text{breakdown @ temp}}}{F_{\text{age}} F_{\text{size}} F_{\text{safety}}}$$

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$$E_{\text{design}} = \frac{E_{\text{breakdown @ temp}}}{F_{\text{age}} F_{\text{size}} F_{\text{safety}}}$$

40

2,2 - 3,8      2,2      1,1



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## What Is The Outcome?

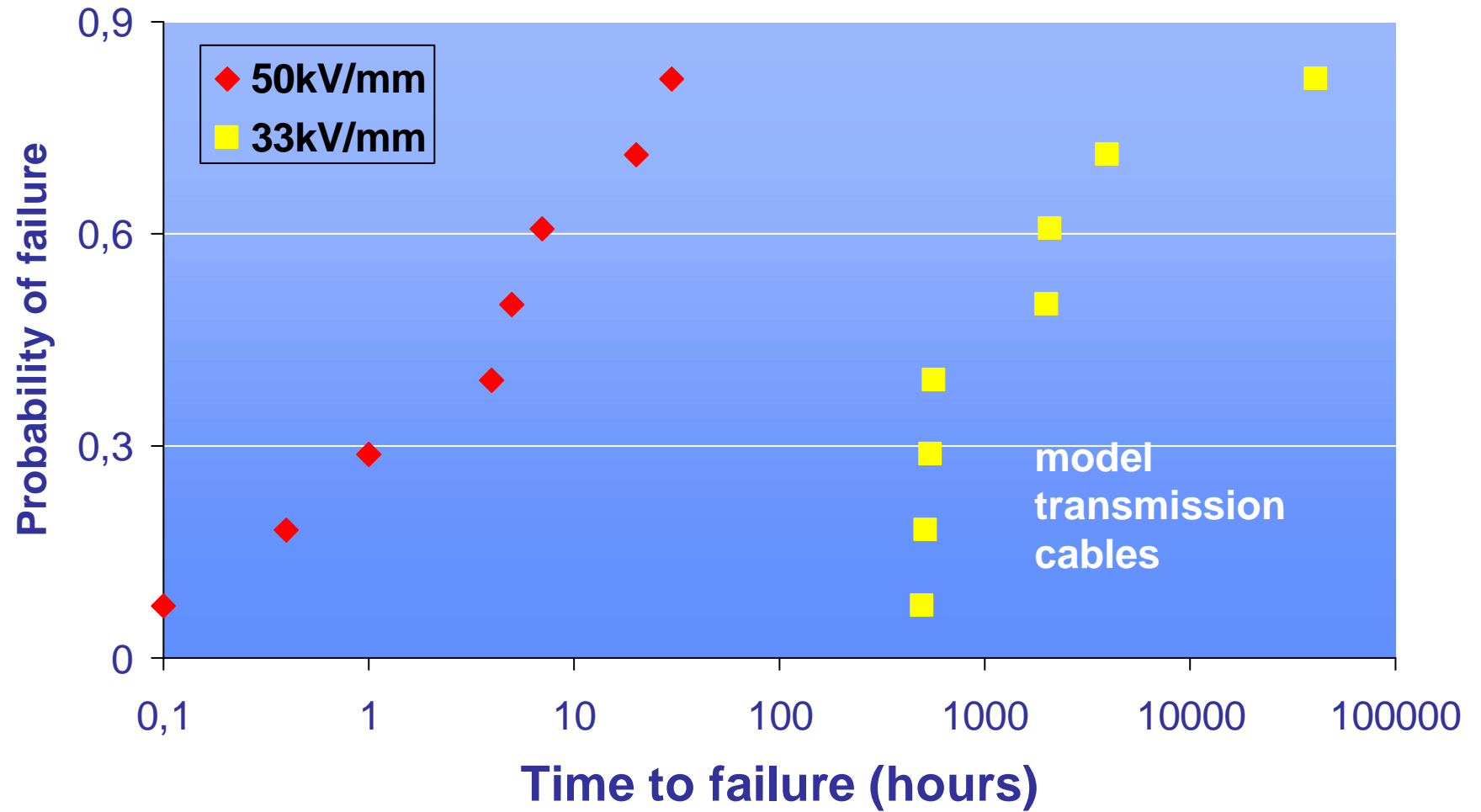
40

$$E_{\text{design}} = \frac{E_{\text{breakdown @ temp}}}{F_{\text{age}} F_{\text{size}} F_{\text{safety}}}$$

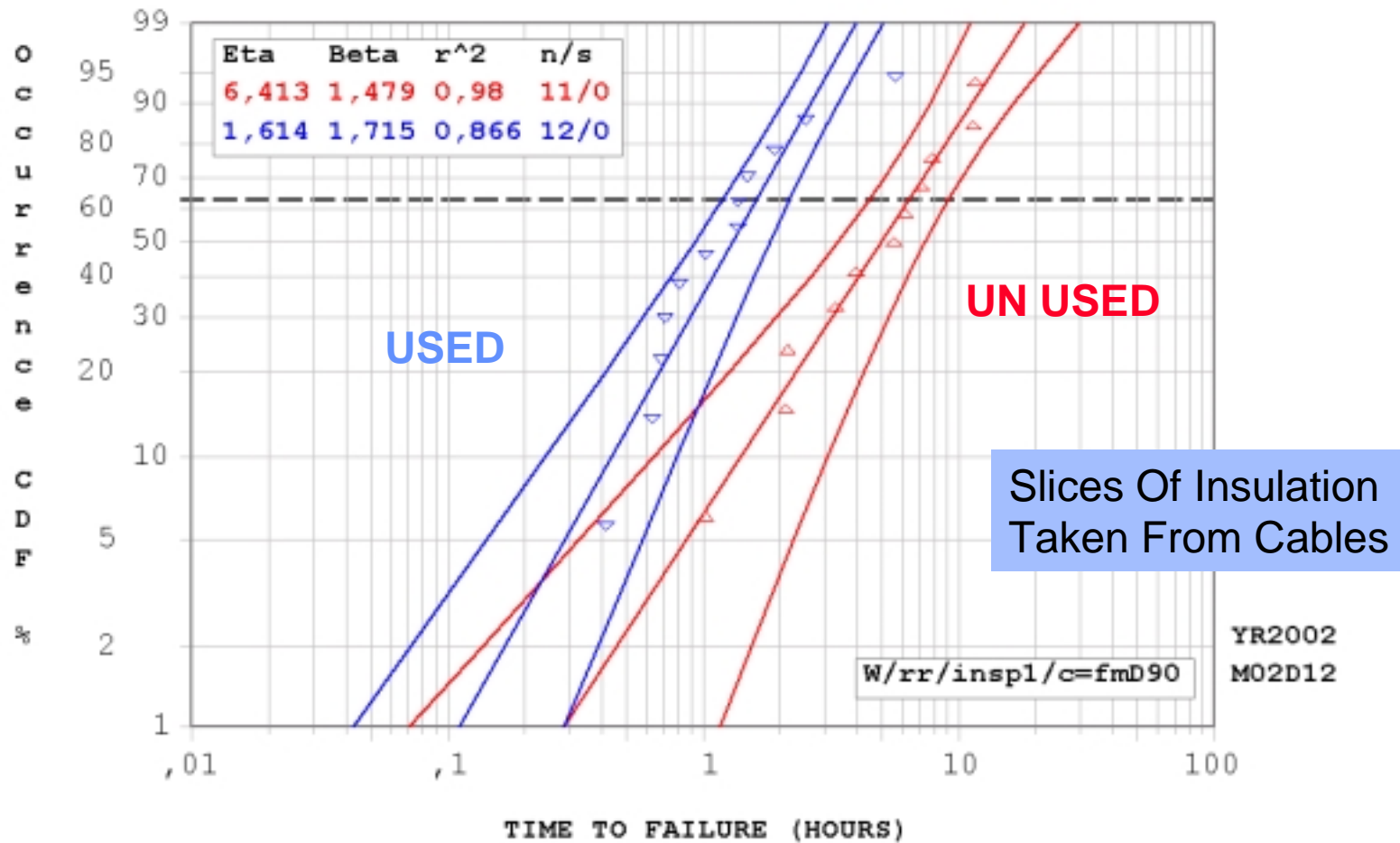
2,2 - 3,82,21,1

$$E_{\text{design}} = \frac{40}{3 * 2.2 * 1.1} = 5.5 \text{ kV / mm} \quad \text{Thickness} = \frac{150 / \sqrt{3}}{5.5} = 16 \text{ mm}$$

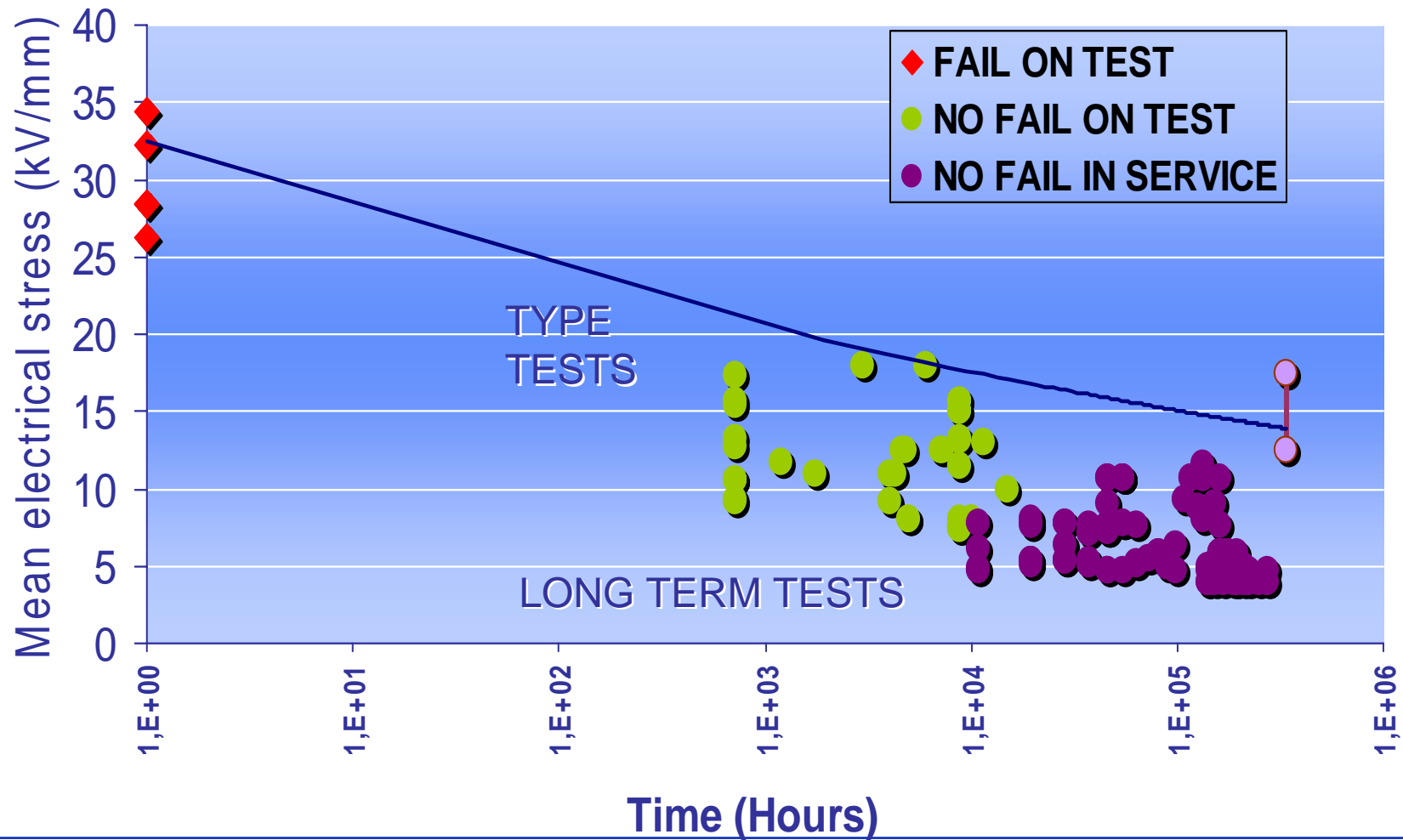
## Endurance Tests



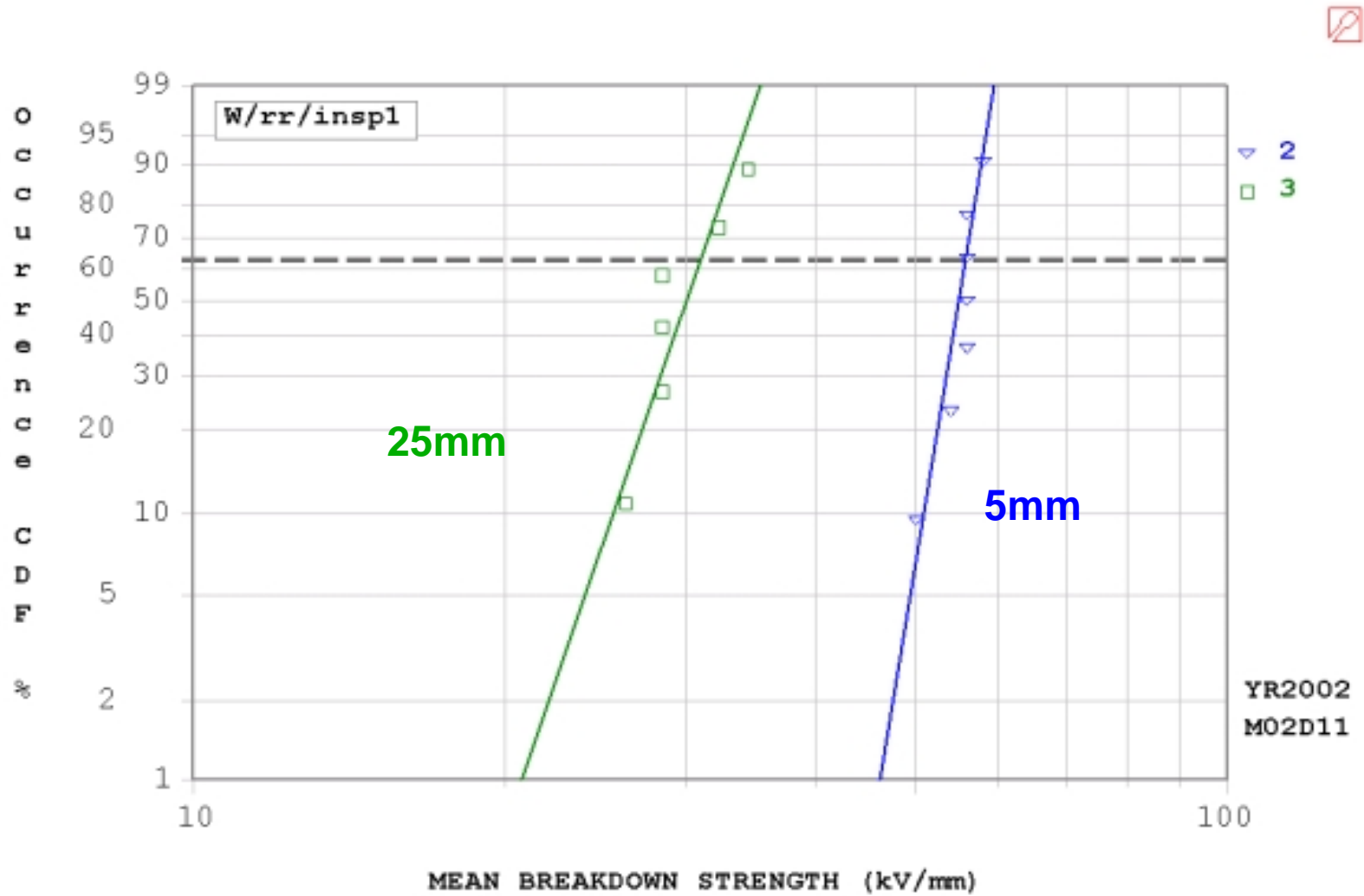
# 115kV cables taken from service after 20 Years



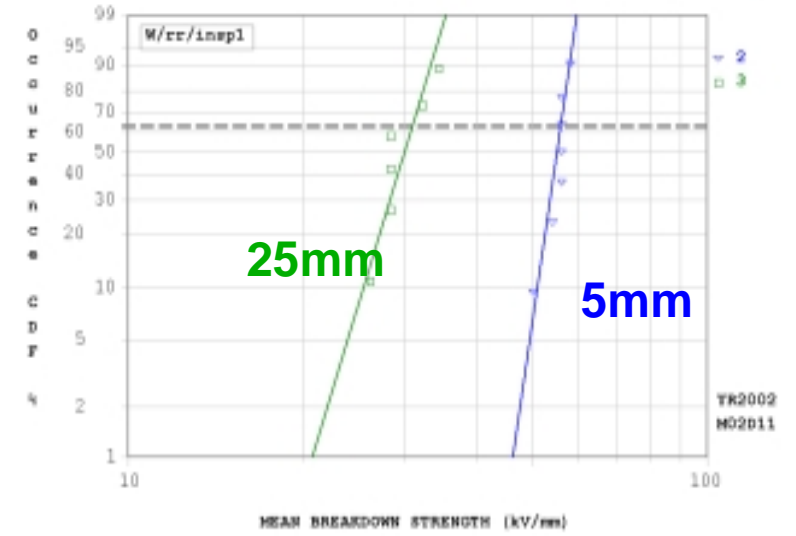
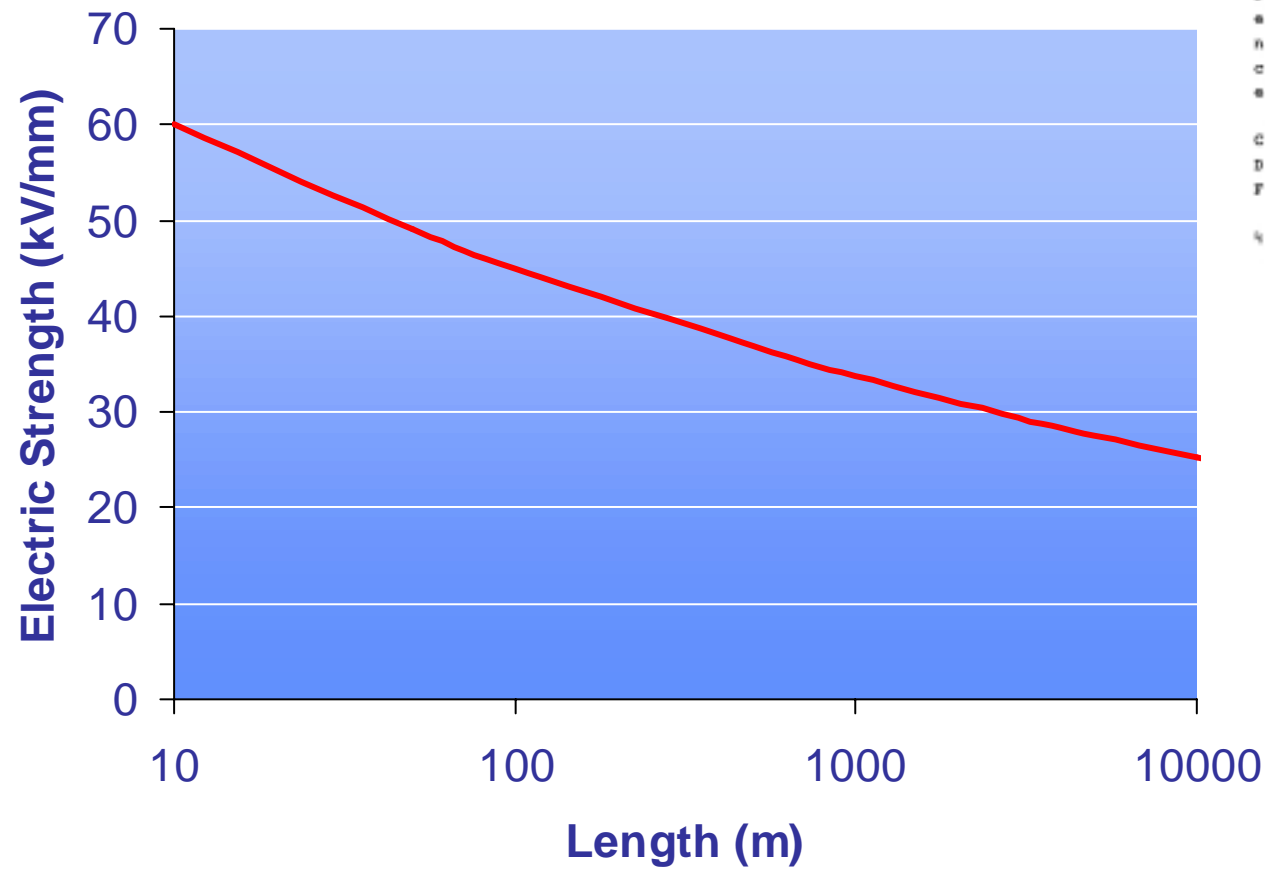
# Endurance Curve - Transmission Cables



# Size



# Size



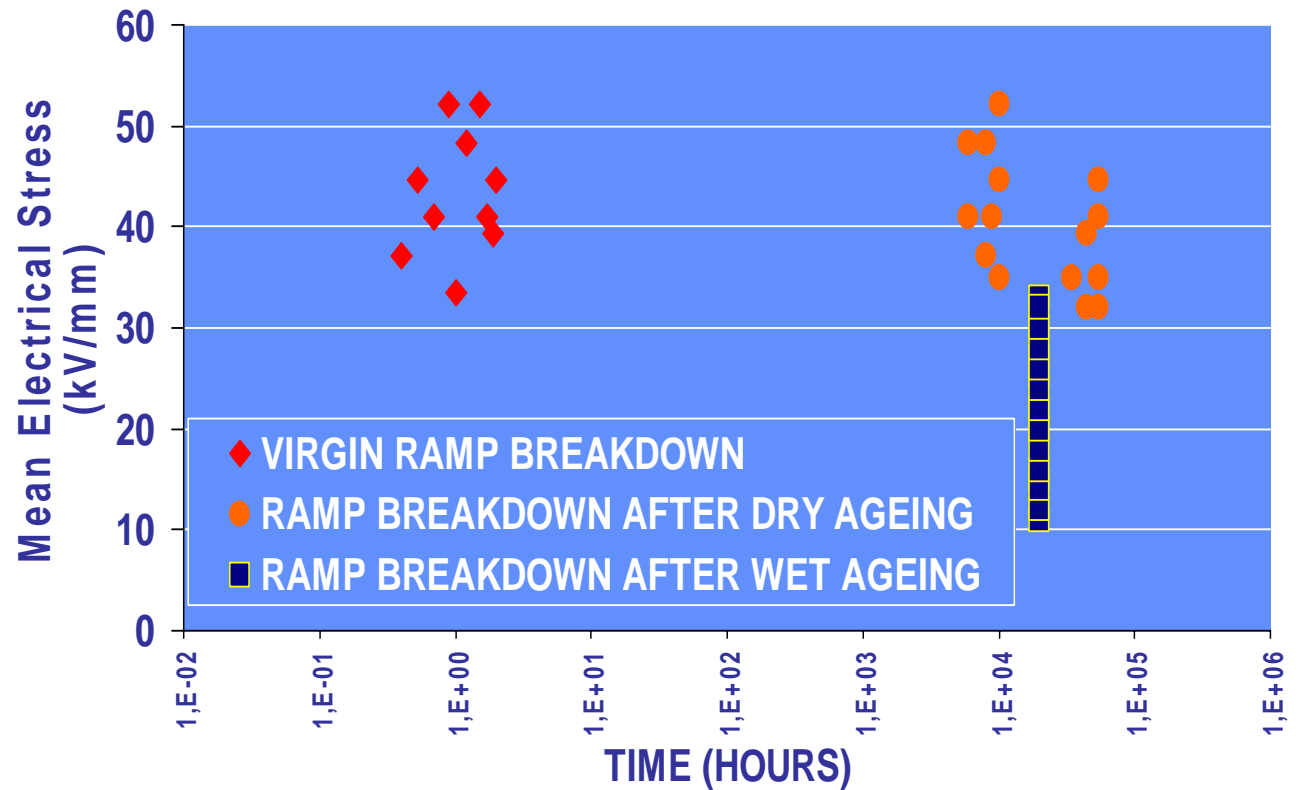
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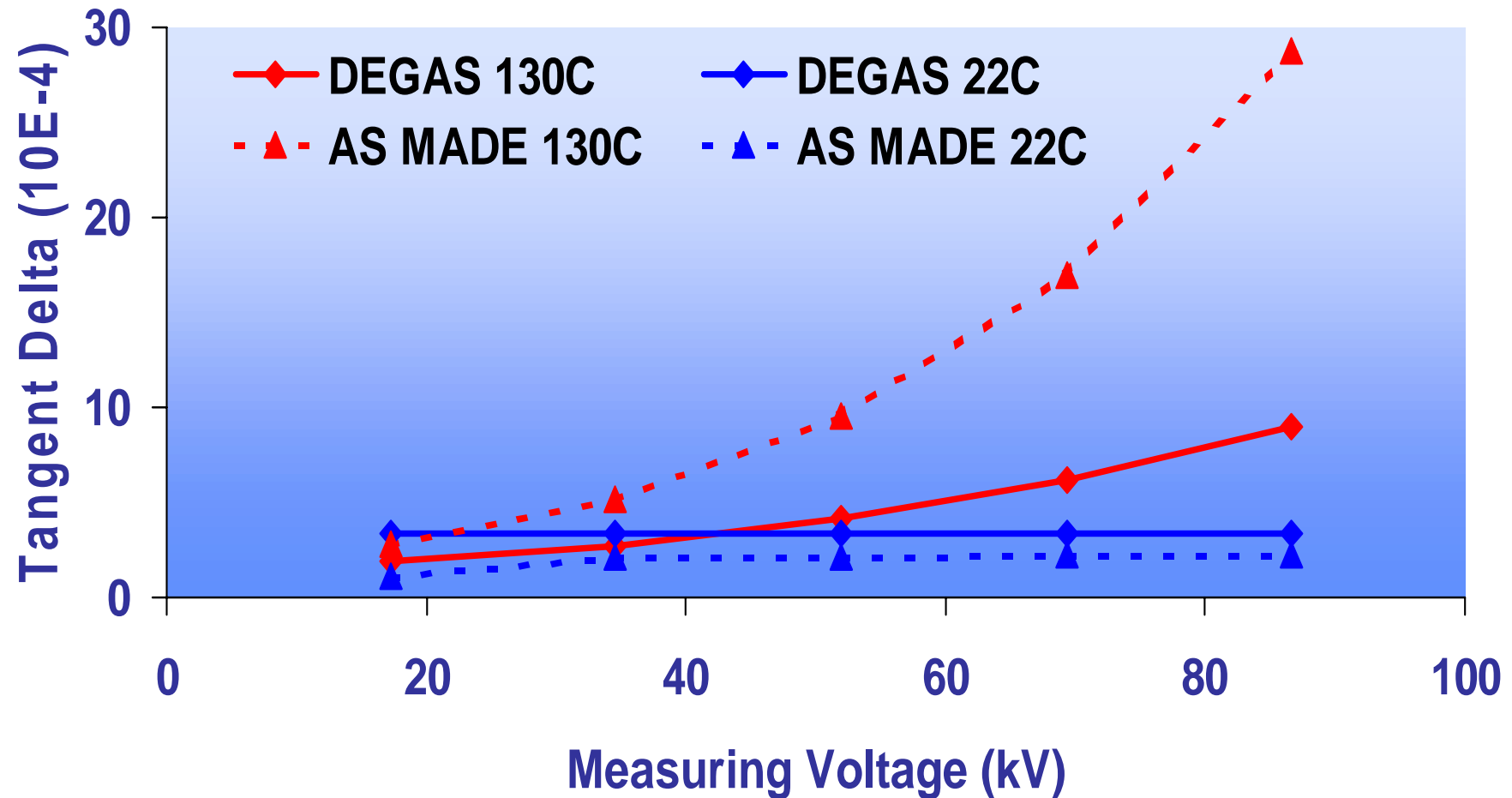
## Water / Moisture Remains A Concern

- Moisture Has A Dramatic Effect On Ageing
- Water Barrier Has To Be Effective And Protected
- Oversheaths & Jackets Are Important Parts Of The Cable Design



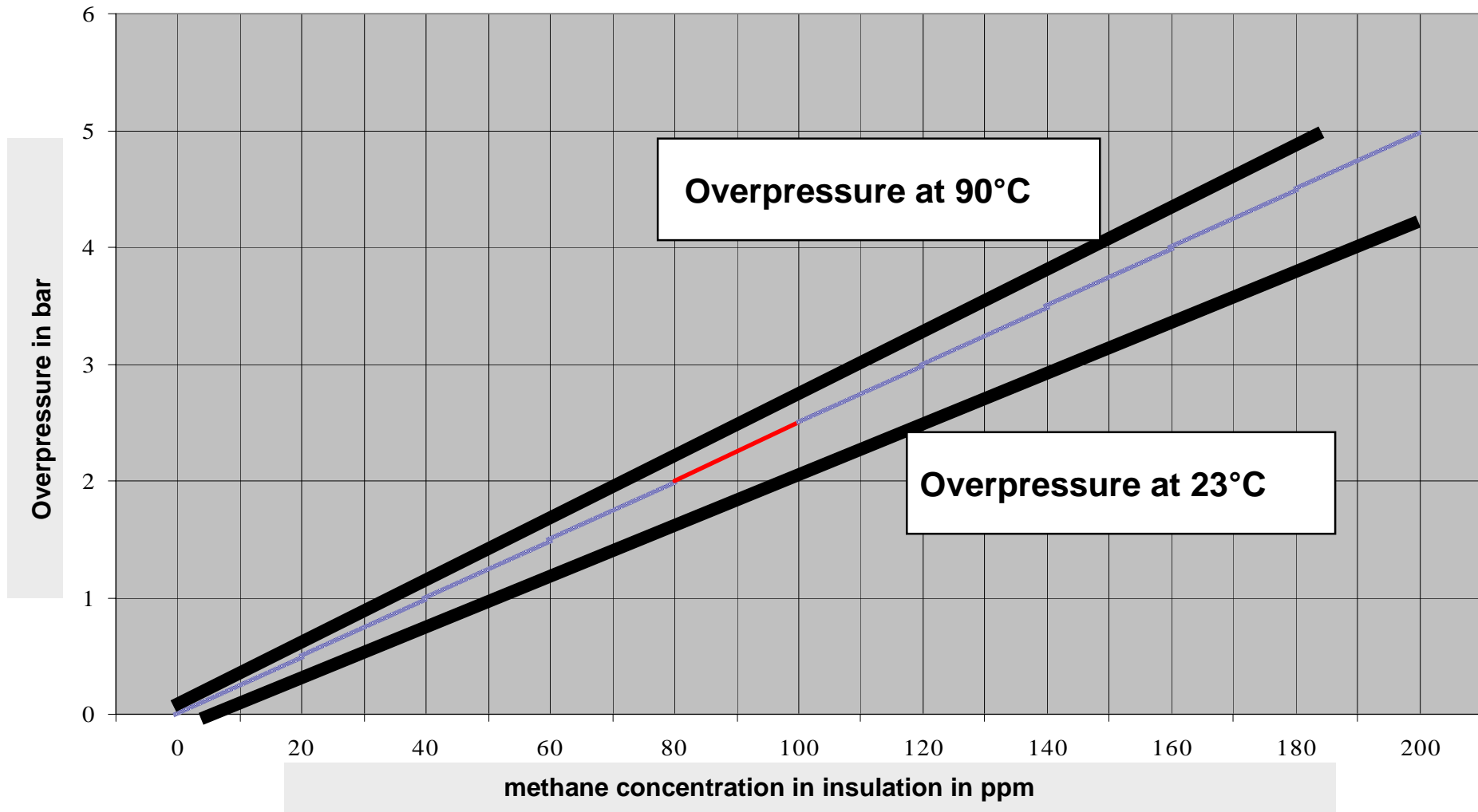


## Dielectric Loss Measurements - HV Cable Models



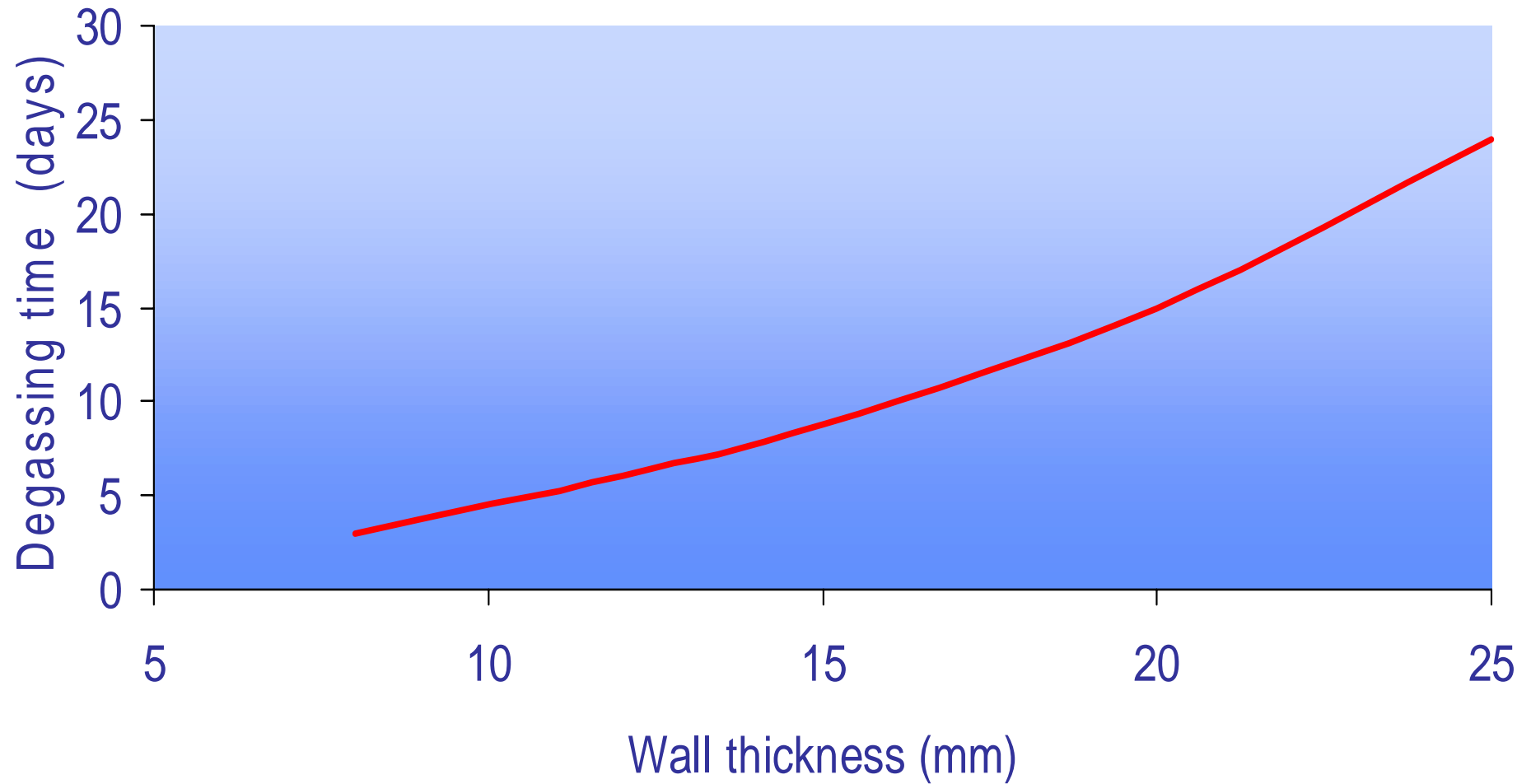
Industry Standard HV Insulation

# 110kV Foil Laminate Sheathed Cable



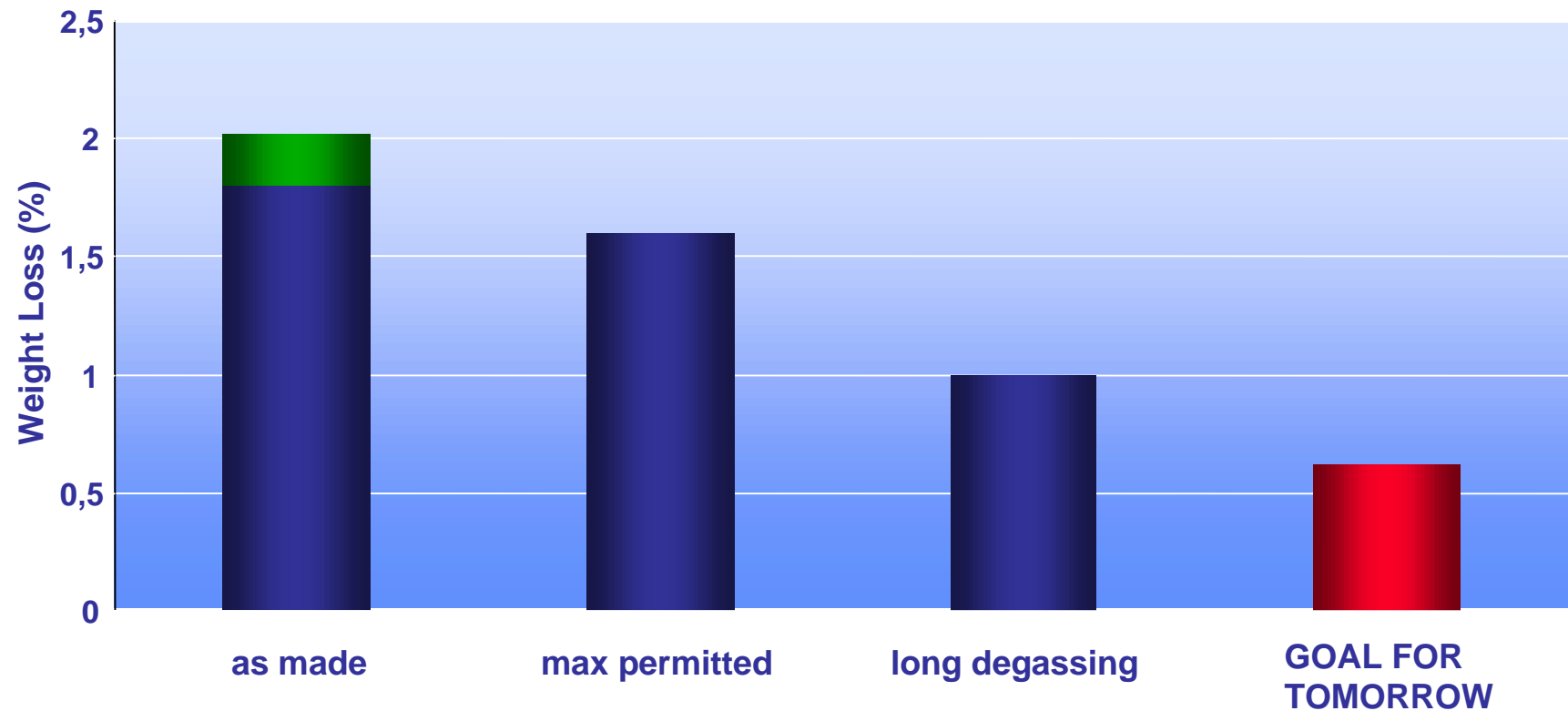
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## Time taken for Degassing

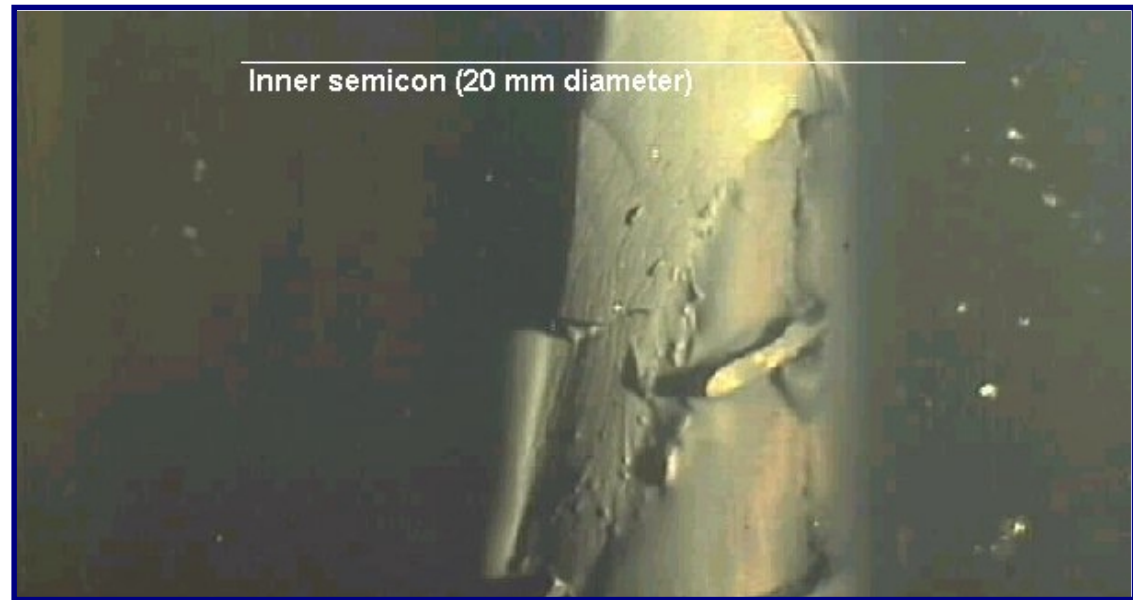
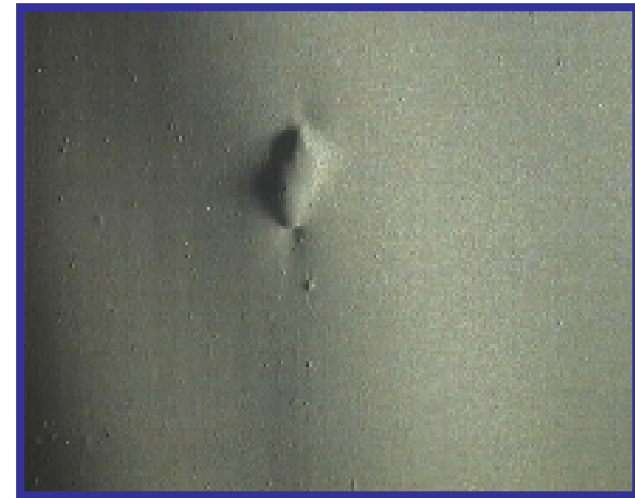
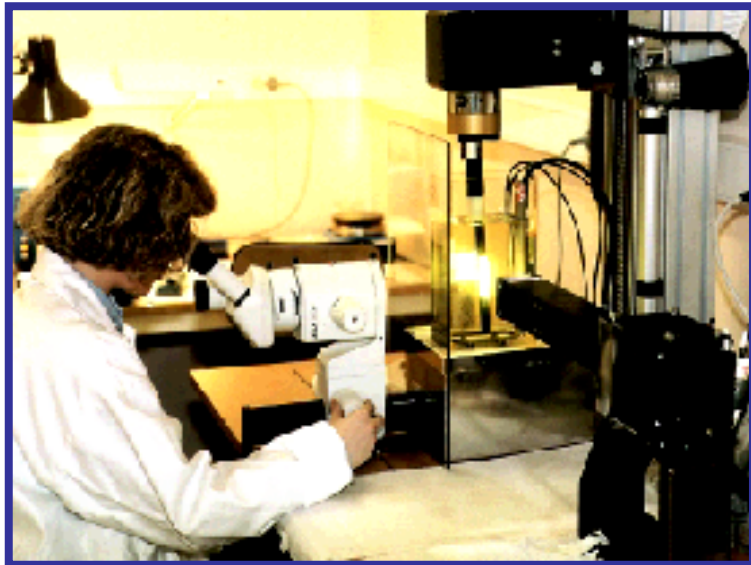


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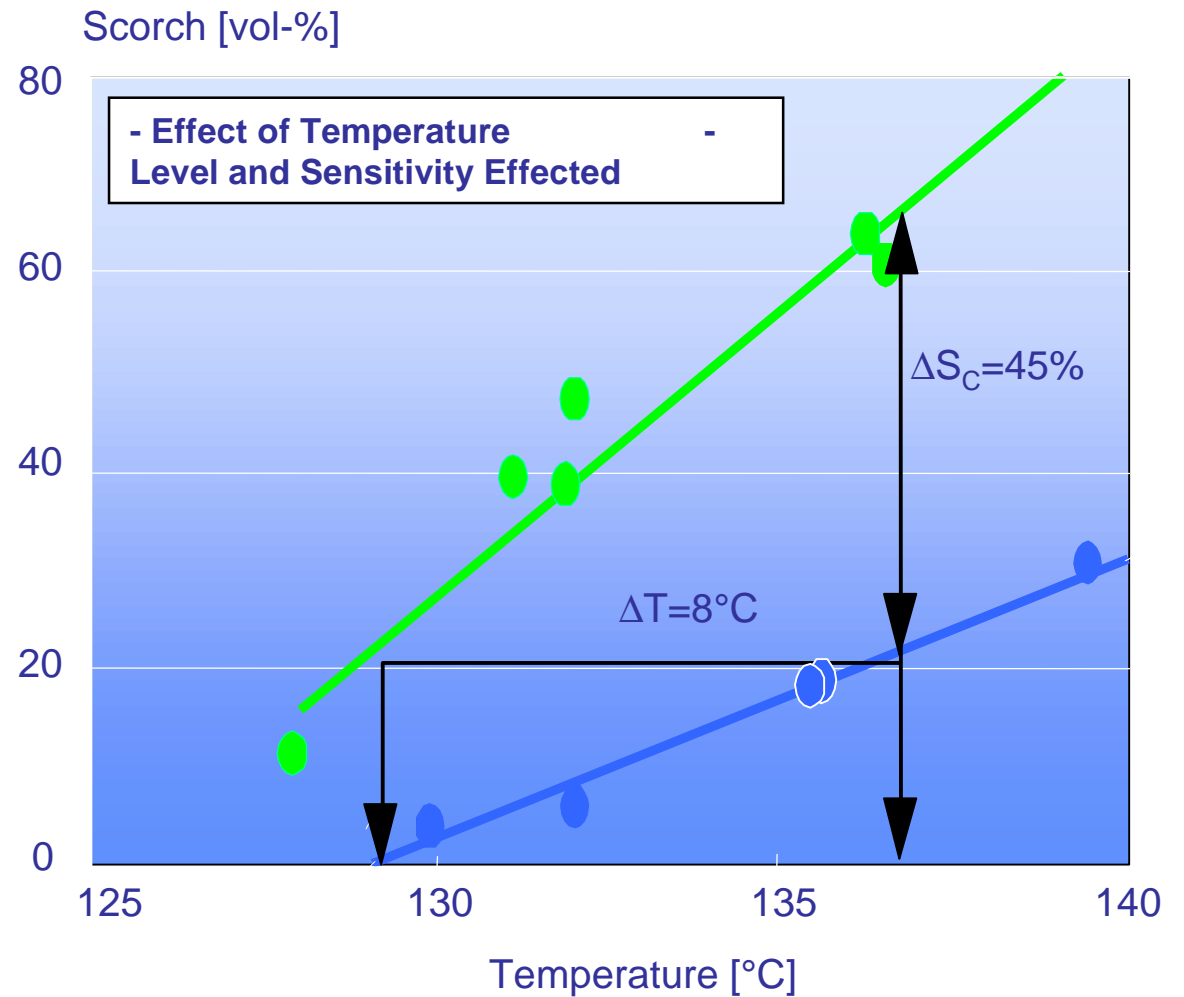
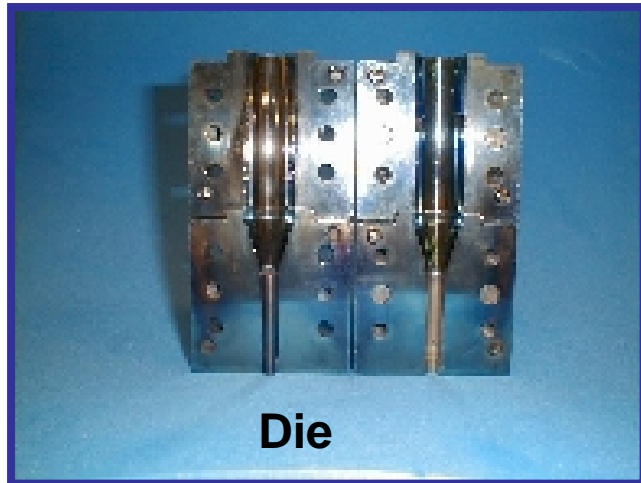
## Degassing Data - TGA Method HD632



# Cable Inspection, Hot Oil Test

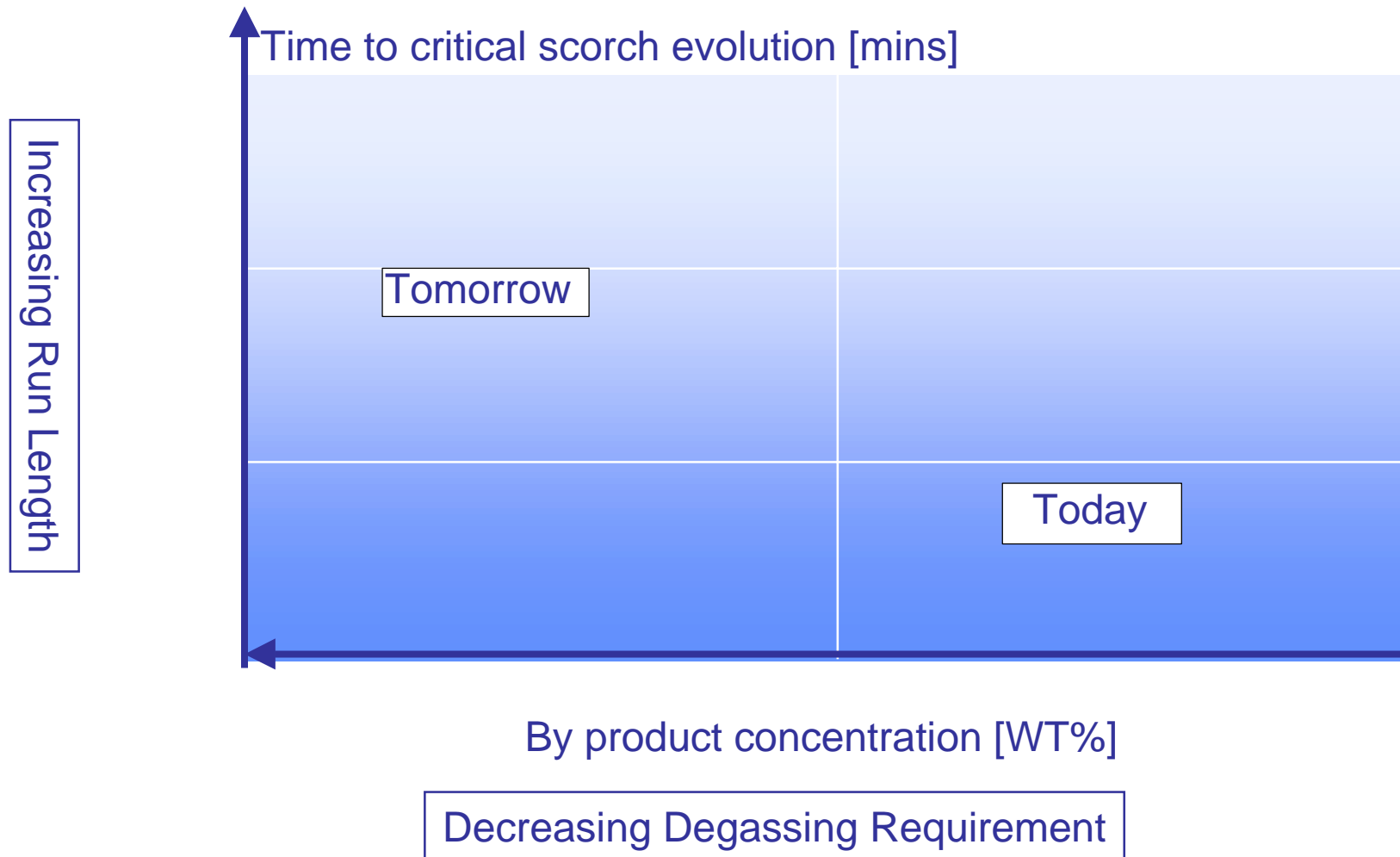


# “The Carrot Scorch Test”



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## Optimal Parameters For High Productivity



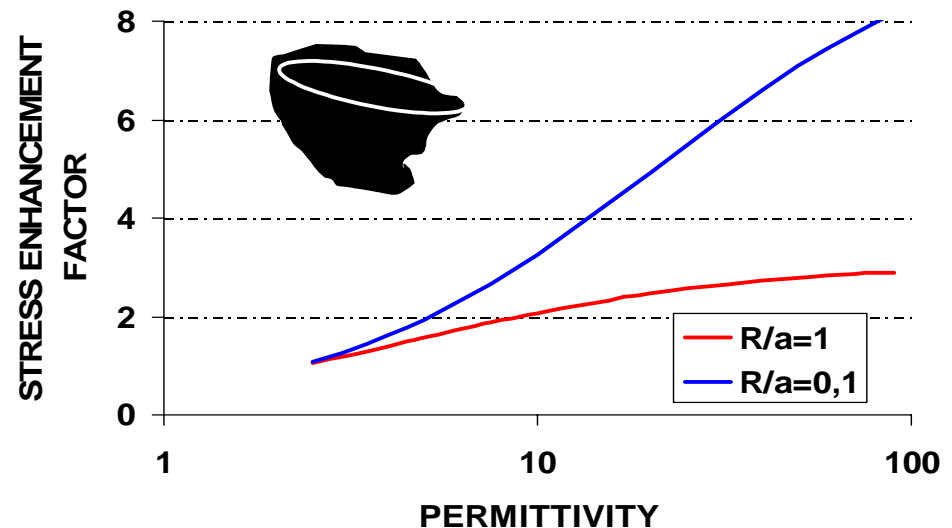
# CLEANLINESS - TAPE TEST

SIZE RANGE (MICRONS)	HV TECHNOLOGY	MV TECHNOLOGY
50 – 70	-	-
70 – 100	10	-
100 – 200	0	3

**NUMBER AND SIZE IS NOT EVERYTHING!**

**HOW DO WE ALLOW FOR DIFFERENT:  
MATERIALS  
SHAPES**

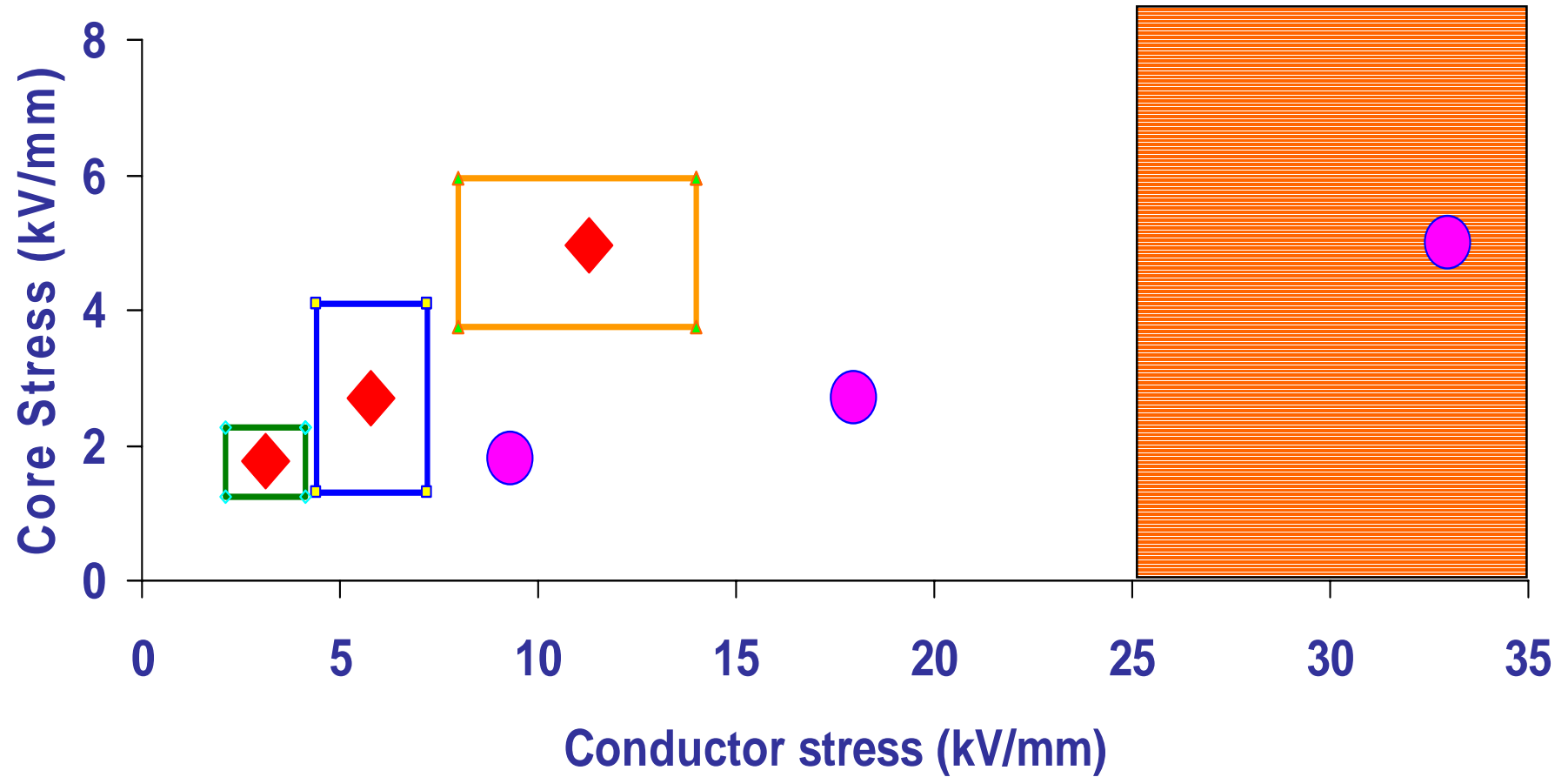
**WE NEED A SMARTER SET OF CRITERIA!!**





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## Electrical Stresses



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## Conclusions

- XLPE HV Cables have come a long way and have some exciting challenges ahead
- Much of the technology is well established and known
- Challenges for the future
  - use of proven EHV technology to downsize
  - long lengths
  - increased need

ATTENTION TO DETAIL



RELIABILITY