



# Accelerated Test Determination of Creep Properties for Different P24 Steel Weldments

**Roman ŠTURM, Janez GRUM**

Faculty of Mechanical Engineering,  
University of Ljubljana, Slovenia  
[roman.sturm@fs.uni-lj.si](mailto:roman.sturm@fs.uni-lj.si)



## ABSTRACT

---

The main aim of the experimental work described is to show the possibilities of small punch creep testing (SPCT) method for assessment of material creep properties.

This paper is concerned with creep properties of P24 steel weldments.

Experiments have shown that the small punch test can be used to describe the time to failure by means of an equation of the Dorn type, in which stress is replaced by load.



## EXPERIMENTAL PROCEDURE

---

T/P24 low-alloyed type of flux-covered manual metal arc welding electrodes was used for the experiments.

The T/P24-type **all-weld metal** was tested in two conditions:

- In the as-welded (AW) condition, without any heat treatment after welding,
- With a PWHT after welding (690 °C x 2h, 150 °C/h to 400 °C, cooling in air).

Furthermore, base metal P24 was creep tested too.



## EXPERIMENTAL PROCEDURE

Mechanical properties of the T/P24 all-weld metal and of base metal P24 at different testing temperatures.

Material	Test temp. (°C)	Yield stress (MPa)	Tensile strength (MPa)	Elongation (%)	Reduction of area (%)	Hardness (HV3)
T/P24 (AW) Weld metal	20	725	841	19	65	299
	500	626	720	15	62	
	620	450	471	19	68	
T/P24 (PWHT) Weld metal	20	547	648	22	72	212
	500	451	471	20	73	
	620	313	323	22	83	
P24 Base metal	20	482	598	24	79	201
	500	372	409	18	81	
	620	284	293	23	89	



## EXPERIMENTAL PROCEDURE

---

SPCT technique: disk-shaped test specimens with a diameter of 8 mm and a thickness 0.5 mm were cut from the weld and from the base metal.

The SPCTs were carried out at temperatures from 580 °C to 640 °C, and at loads from 250 to 520 N.

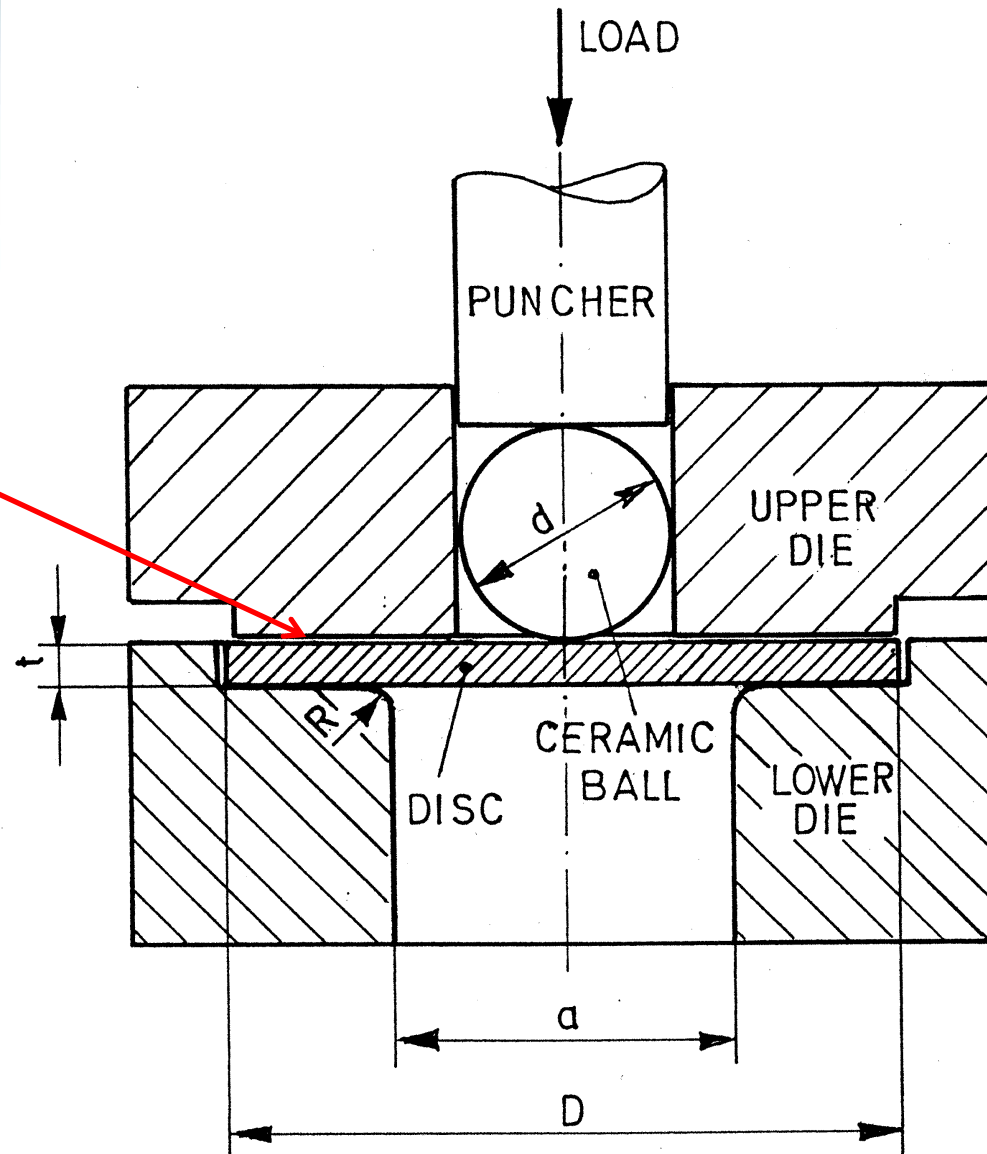
A conventional uni-axial constant-load tensile test specimen was also cut from the all-welded metal T/P24 and from the base metal P24, and later also from the cross-weld.

A conventional constant-load creep tests were performed at temperatures between 600 and 660 °C and at initial stresses of 60 to 180 MPa.



# EXPERIMENTAL PROCEDURE

a loose fitting



$d = 2.5 \text{ mm}$

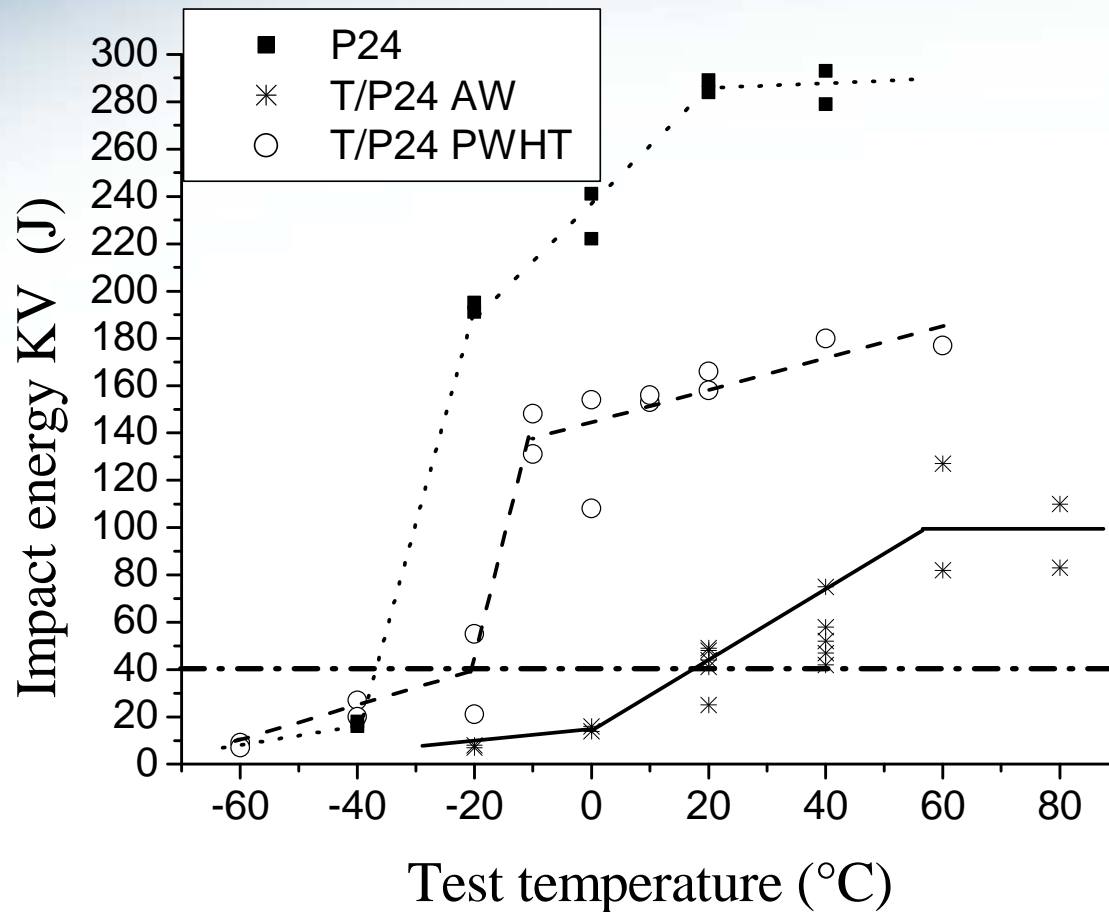
$t = 0.5 \text{ mm}$

$a = 4 \text{ mm}$

$R = 0.2 \text{ mm.}$



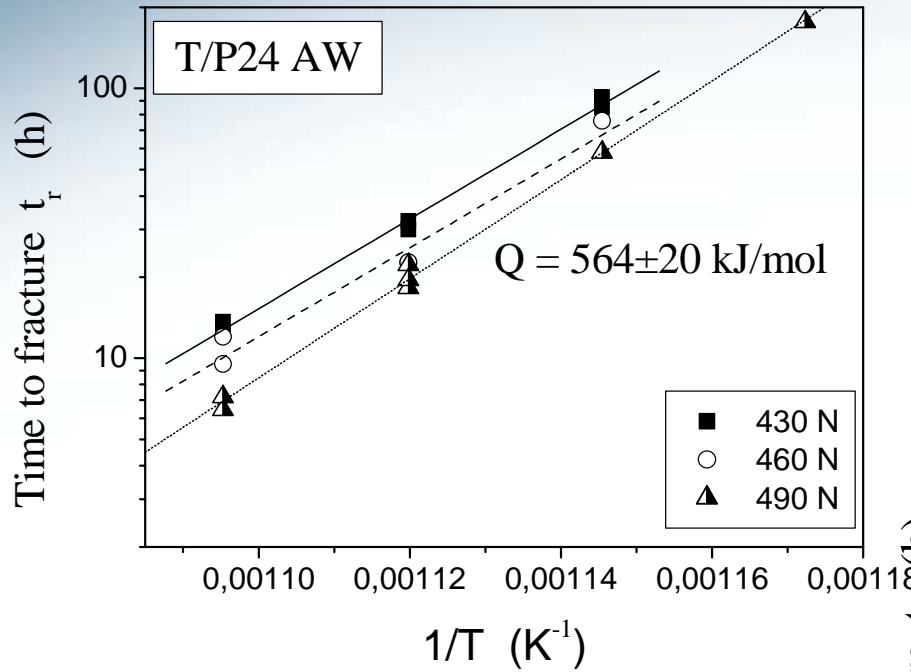
# RESULTS - Impact toughness



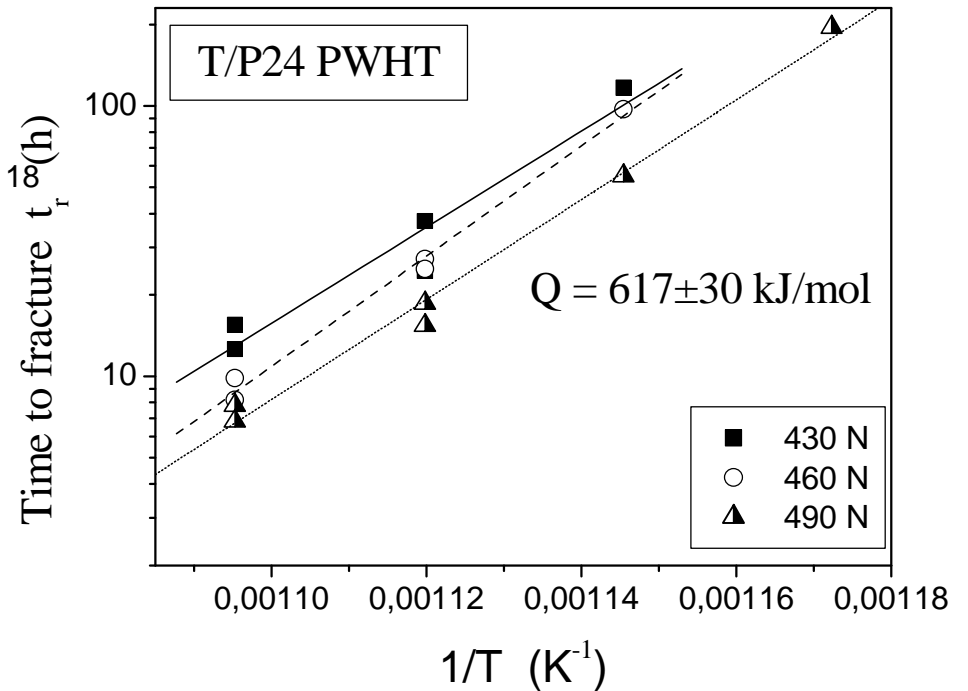
The recommended minimum impact energy for cold welding is 40 J.



# RESULTS - Accelerated small-punch creep test results

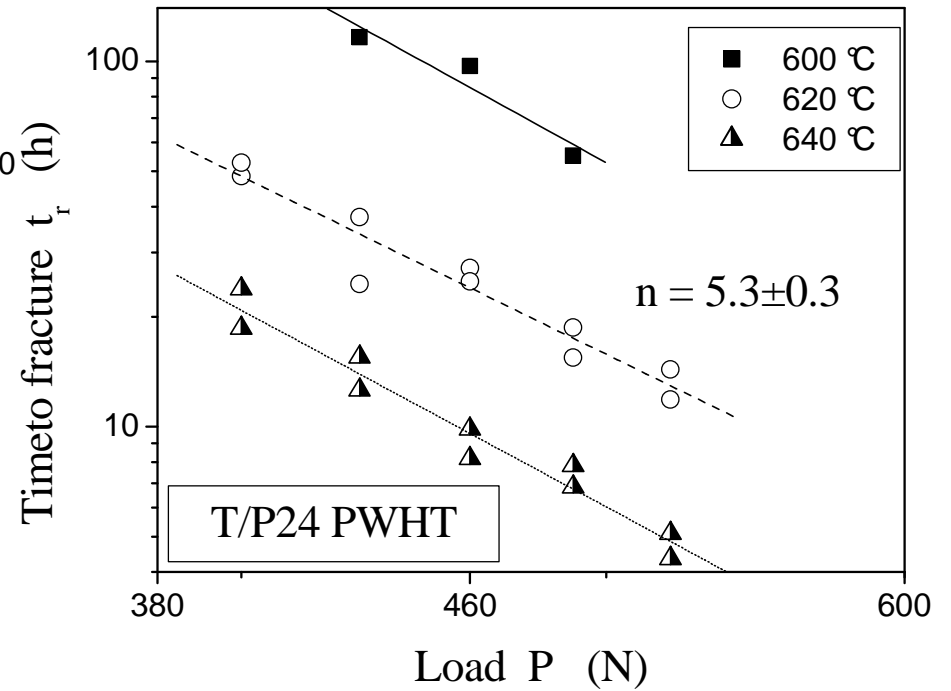
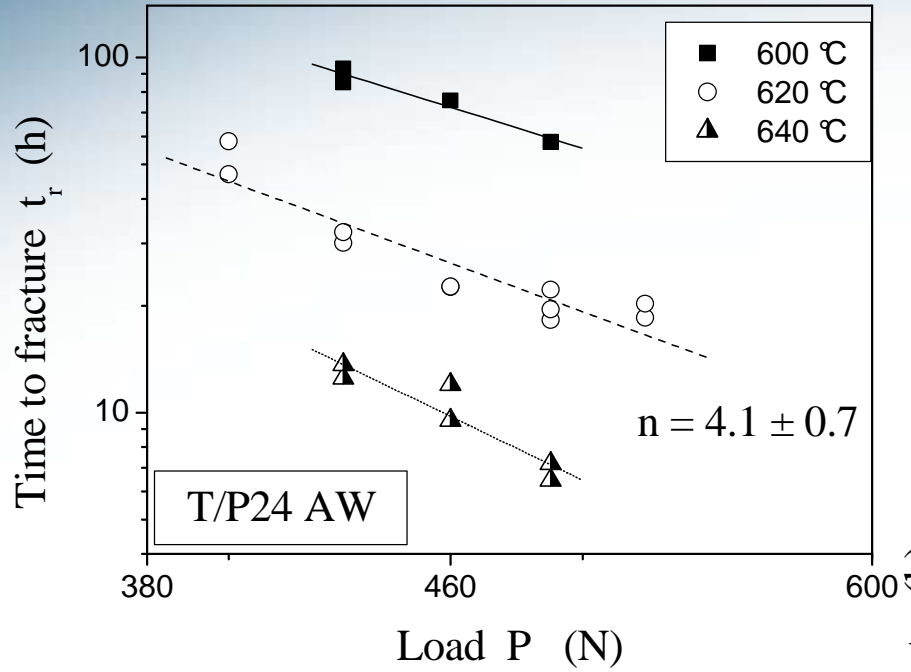


$$t_r = B \cdot P^{-n} \cdot \exp\left(\frac{Q}{RT}\right)$$





# RESULTS - Accelerated small-punch creep test results





## RESULTS - Evaluation of accelerated creep test results

We have performed also conventional constant-load creep tests at testing temperatures of 600, 620 and 660 °C and with initial stresses of 60, 80, 100, 130, 160 and 180 MPa.

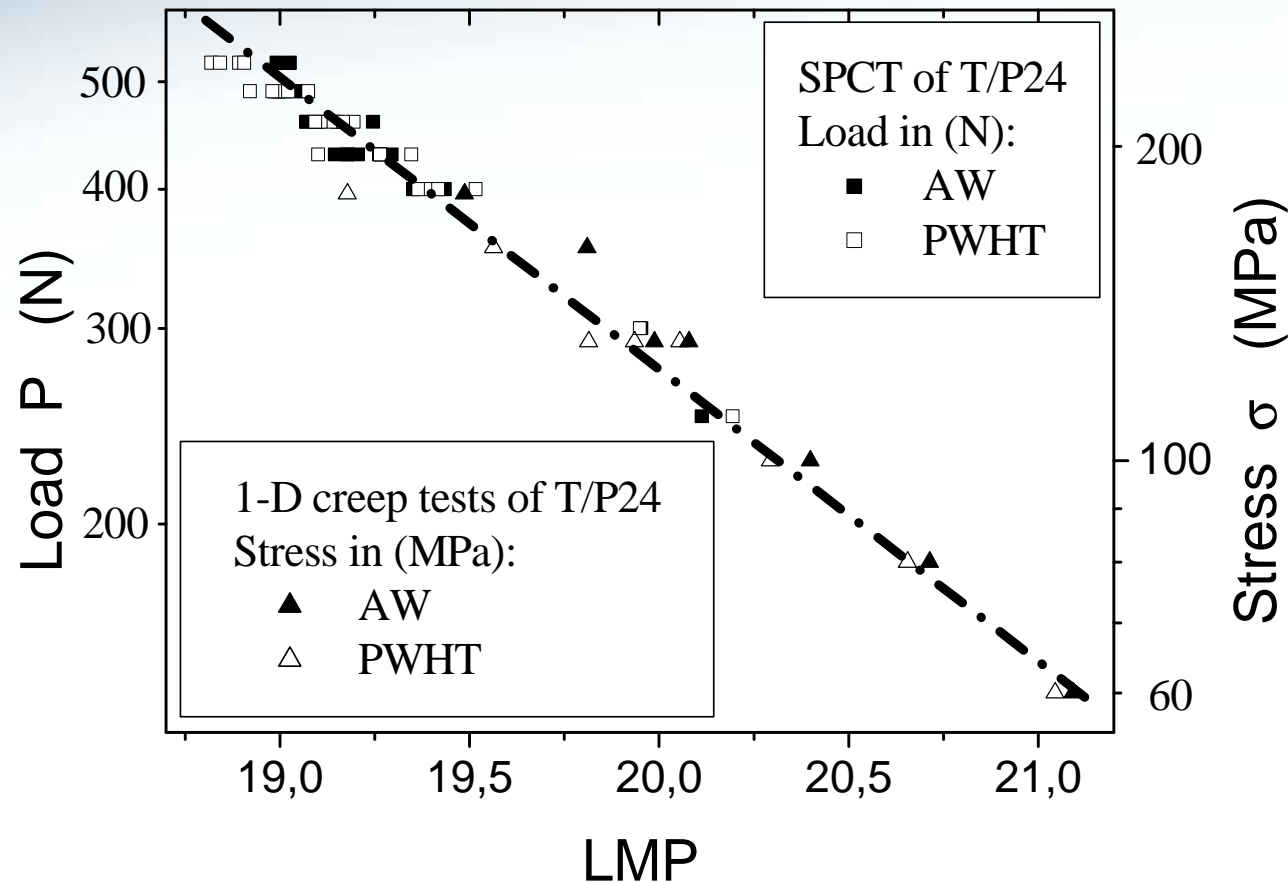
The results were expressed using a Larson–Miller-type aging parameter (LMP):

$$\mathbf{LMP = (T + 273) \cdot (C + \log t_r) \cdot 10^{-3}}$$

All creep-rupture data of the all-welded metal T/P24 in two different conditions, i.e. with and without a PWHT, obtained at small-punch and conventional uni-axial constant-load devices, were converted to a LMP and plotted in one graph only.



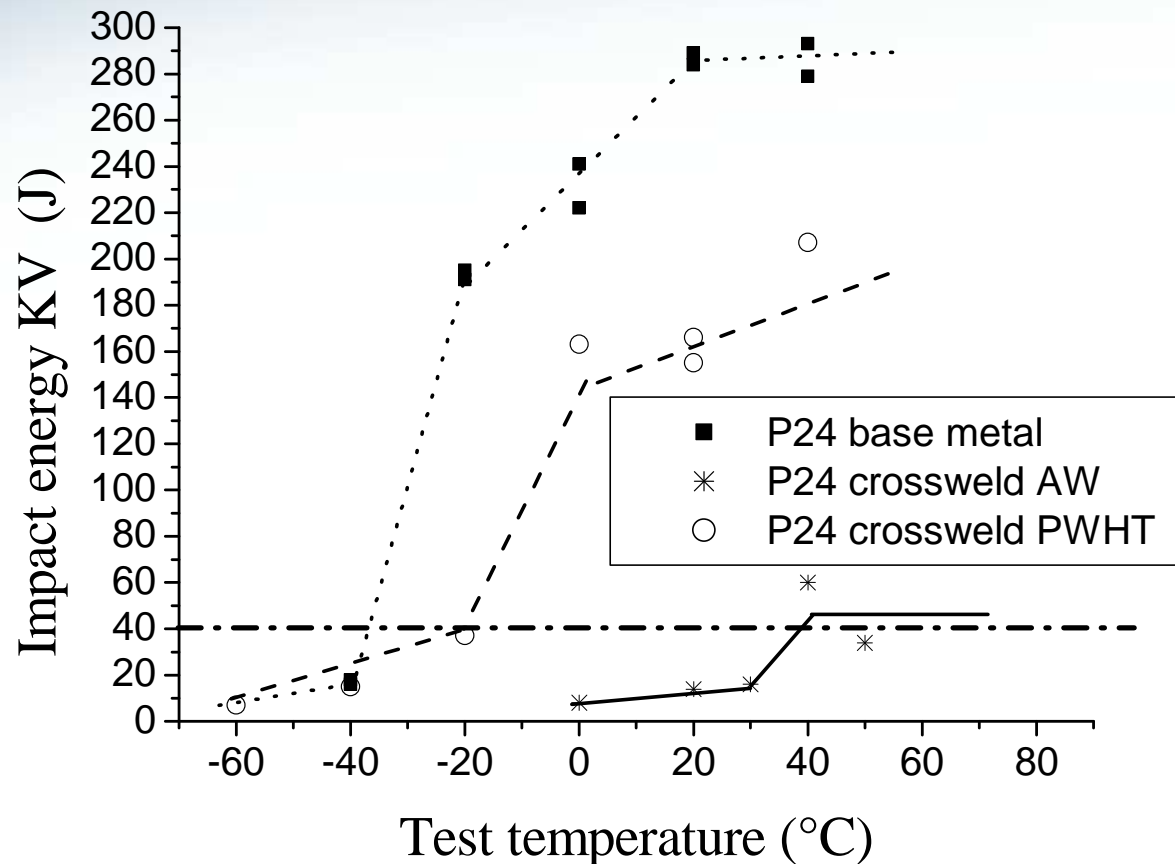
## RESULTS - Evaluation of accelerated creep test results



It was confirmed that during the accelerated creep measurements the load  $P$  (in N) applied during the small-punch creep testing has to be approximately 2.2 times larger than the stress  $\sigma$  (in MPa) applied during uni-axial constant-load creep testing with the same time-to-rupture.



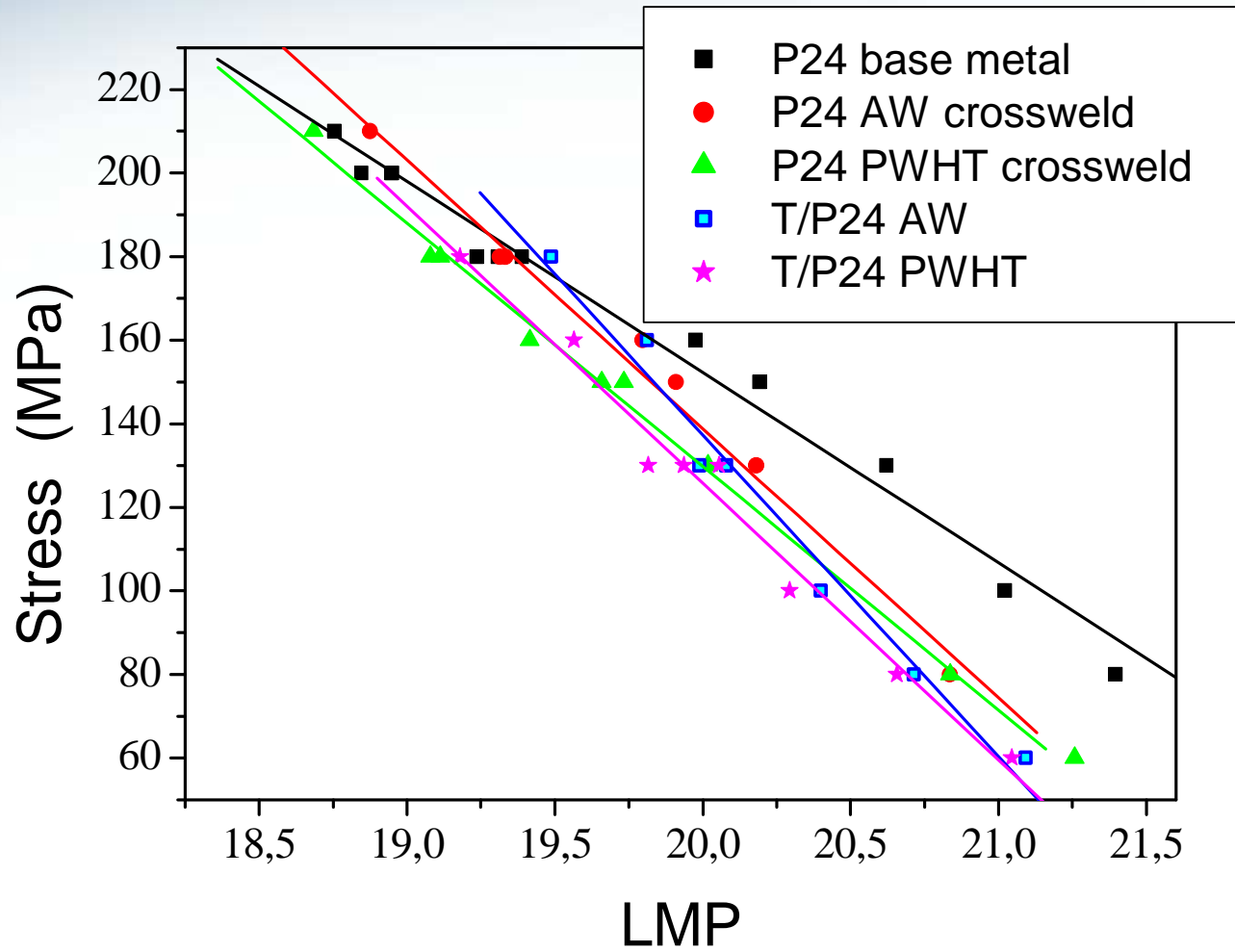
## RESULTS – Impact toughness of real weldment



In as-welded condition, the impact energy of the cross-weld at room temperature is only 14 J.



# RESULTS - Conventional constant load creep testing





## RESULTS - Evaluation of cross-weld creep results

---

- Base metal P24 has better creep resistance than the all-weld metals T/P24 in AW and PWHT.
- We can see that P24 crossweld exhibits better creep resistance in AW condition than in PWHT condition for stresses higher than 80 MPa. At lower stresses, it seems, we will have better creep resistance in PWHT condition.

The rupture position of crossweld creep test specimens:

- At stresses of 180 MPa or higher:
  - test specimen ruptured in the base metal.
- At stresses of 160 MPa or lower:
  - test specimen ruptured in the weld.



## SUMMARY

---

The main advantage of SPCTs in comparison with conventional constant-load creep tests is the small amount of material required for testing to establish the creep activation energies and the load exponents of the investigated material.

We can conclude that according to accelerated creep test results of the investigated T/P24 type weld metal, no PWHT of the welded metal is needed. But the welded joint of P24 base metal and T/P24 welding metal shows the impact toughness of values 14 J in as-welded condition .



## SUMMARY

---

A comparison of the creep-testing result using the Larson-Miller parameter confirmed that for similar rupture times during accelerated creep tests, the load  $P$  (in N) for small-punch testing should be 2.2-times larger than the stress  $\sigma$  (in MPa) for uni-axial creep-testing.

The results of accelerated SPCTs carried out on P24 steels have shown that the SPCT is an appropriate testing methodology for the characterization of as-welded joints.

When we want to produce welded joints without any post-weld heat treatment, we should apply new types of welding consumables that give softer all-weld metals with a higher initial toughness.