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Institut für Baustoffe, Massivbau und Brandschutz | Materialprüfanstalt für das Bauwesen

Test Report

- Translation -

Document No.:	(3319/384/09)-NB dd. 04/03/2009
Client:	FRIULSIDER SPA Via Trieste 1 33048 San Giovanni al Natisone Italy
Order date:	09/02/2009
Order Ref.:	Ms Novello, Mr Veneziano
Order received:	09/02/2009
Subject:	"Friulsider Injection system KEM-UP + Vinylester" bonded anchors, placed in the non-cracked tension zone of RC floor sections, strength class ≥C20/25, and subjected to centric tension loads, to be tested and evaluated in connection with anchor rods (dimensions M8 to M30) for their reaction to fire to determine their fire resistance time
Test basis:	DIN EN 1363-1 : 1999-10
Test material received:	Week 46/2006
Sampling:	The Testing House does not have any information indicating official sampling.
Test material marking:	None
Test date:	21/11/2006, 28/11/2006, 06/12/2006, 24/01/2007 and 20/02/2007
Valid until:	06/03/2013

Materialprüfanstalt f. d. Bauwesen Braunschweig MPA BS 3.1

This Test Report consist of 8 pages, incl. cover and 11 annexes.

The Test Report No. (3319/384/09)-NB dated 04/03/2009 does not replace a General Building Code Test Certificate (abP; abZ, ETA) according to the German Laender Building Regulations.

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Notified body (0761-CPD)
MPA Braunschweig has been approved and notified as a civil engineering supervisory, inspection and certification body. MPA Braunschweig has been ISO/IEC17025 accredited as a testing and calibration laboratory and ISO/IEC17020 accredited as an inspection body.

Contents

1 Background and general statement

Under the order placed with the Testing House, a Test Report was to be drawn up on the reaction to fire of "Friulsider Injection system KEM-UP + Vinylester" bonded anchors, which are subjected to centric tension and tested for steel failure in compliance with section 2.3 of TR 020 : 2004-05, when exposed to a fire in compliance with DIN EN 1363-1 : 1999-10 to determine their fire resistance time.

Related documents:

(1) DIN EN 1363-1 : 1999-10, Fire resistance tests - Part 1: General requirements,

(2) EOTA Technical Report TR 020 : 2004-05 - Evaluation of anchorages in concrete concerning resistance to fire,

(3) "Friulsider Injection system KEM-UP + Vinylester", European Technical Approval ETA-08/0383 of 15-01-2009, issued by DIBt, Berlin,

(4) is a transfer of Test Report No. (3290/0966)-NB dated 06-03-2008. The injection adhesive anchors evaluated in the present Test Report are per statement of the client identical with the anchors evaluated in the Test Report No. (3290/0966)-NB.

This document is the translated version of Test Report No. (3290/0966)-NB dated 06-03-2008. The german version is the only legally binding text.

Using the results achieved in the fire test, the "Friulsider Injection system KEM-UP + Vinylester" bonded anchors were to be examined and evaluated respecting requirements (steel failure, pullout) specified in EOTA Technical Report TR 020 : 2004-05.

2 Description of system tested

The "Friulsider Injection system KEM-UP + Vinylester" bonded anchor is an injection system that uses the bonding effect between anchor rod, bonding mortar and concrete to become anchored in the substrate. According to the type approval for cold design of anchoring means primarily subjected to static loads, the "Friulsider Injection system KEM-UP + Vinylester" bonded anchor may be used in reinforced and non-reinforced normal-weight concrete (strength class C20/25 as a minimum and C50/60 as a maximum) in the non-cracked concrete.

Main elements of the tested "Friulsider Injection system KEM-UP + Vinylester" bonded anchor are a two-component mortar cartridge (injection mortar: styrene-free vinylester resin system with cement, water and sand) and cold-formed anchor rods (dimensions M8 to M30), together with a hexagon nut and a washer. The anchor rods and the nuts and washers are made from electro-galvanized steel (strength class $\geq$5.8) and from stainless steel (material No. 1.4401 (A4) and 1.4571 (A5), 1.4529 (HCR), strength class 70). Forces are transmitted by the bond stress between the anchor rod and the anchoring substrate. For the service conditions, the "Friulsider Injection system KEM-UP + Vinylester" bonded anchor is regulated by the above-named approval.

As specified in the above type approval, the "Friulsider Injection system KEM-UP + Vinylester" bonded anchors were installed with the installation tools (hammer drill and drill, cleaning device and injection device) defined in these documents.

Further structural details and details of the as-installed condition of the bonded anchors are shown annexes 1.1 to 1.4 of this Test Report.

3 Test set-up and testing

The "Friulsider Injection system KEM-UP + Vinylester" bonded anchors were fire tested in a small-sized furnace with the inside dimensions 1,000mm x 1,500mm x 1,500mm (WxDxH). RC

slabs (strength class C20/25) formed the horizontal barrier, into the tension zones of which the "Friulsider Injection system KEM-UP + Vinylester" bonded anchors were placed.

In compliance with TR 020 : 2004-05, section 2.3.1, external loading systems and protected steel elements (dead loads) of the required weight, which were suspended for an unsupported and unprotected length of l ≤500mm with tension rods and an additional steel adapter, were used for introducing the centric loads into the "Friulsider Injection system KEM-UP + Vinylester" bonded anchors.

The furnace was exposed to a fire in compliance with the standard temperature-time curve (ETK) as specified in DIN EN 1363-1 : 1999-10, section 5.1.1. The temperatures in the furnace were measured with 2 plate thermometers with measuring heads made from Ni-Cr/Ni-Al wire (type K) dia. 1.0mm in compliance with DIN EN 1363-1 : 1999-10, section 4.5.1.1.

The temperatures measured in the furnace during the fire tests are illustrated by the graphs in annexes 2.1, 3.1, 4.1, 5.1 and 6.1.

4 Test results, evaluation and conclusions

4.1 Evaluation of test results respecting centric tension loading

On 21/11/2006, 28/11/2006, 06/12/2006, 24/01/2007 and 20/02/2007, a total of 23 "Friulsider Injection system KEM-UP + Vinylester" bonded anchors were placed in the non-cracked tension zone of RC floor sections (strength class C20/25) and tested for their reaction to fire when subjected to centric tension loads in compliance with DIN EN 1363-1 : 1999-10 to determine their fire resistance time.

Tables 4-1 to 4-5 in Test Report No. (3290/0966)-NB dated 06-03-2008 list the test results for the 23 "Friulsider Injection system KEM-UP + Vinylester" bonded anchors in connection with anchor rods made from electro-galvanized steel and stainless steel and make reference to the cause of failures.

4.2 Evaluation of test results respecting steel failure

4.2.1 General

The basis used for evaluation was section 2.3.1 of EOTA Technical Report TR 020 : 2004-05:

$\sigma_{s1} = c_1 + c_2 / t_u$ equation: regression curve

$\sigma_{s2} = c_3 (c_1 + c_2 / t_u)$ equation: design curve

Equations for determination of the characteristic steel stress for fire resistance times of 60 min., 90 min. and 120 min:

$\sigma_{Rk,s,fi(60)} = c_3 (c_1 + c_2 / 60min)$

$\sigma_{Rk,s,fi(90)} = c_3 (c_1 + c_2 / 90min)$

$\sigma_{Rk,s,fi(120)} = c_3 (c_1 + c_2 / 120min)$

Equation for determination of the characteristic steel stress for fire resistance times of 30 min., using the equation of the straight line through points t_u = 60 min/ $\sigma_{Rk,s,fi(60)}$ and t_u = 90 min/ $\sigma_{Rk,s,fi(90)}$:

$\sigma_{Rk,s,fi(30)} = c_4 - c_5 \times 30min$

To calculate the tensile stress, the stress cross section A_s of the corresponding diameter of the "Friulsider Injection system KEM-UP + Vinylester" bonded anchors was entered in the computation.

4.2.2 Presentation of test results and evaluation

The graphs in annex 7.1 show the test results as a function of the stress sigma s of the "Friulsider Injection system KEM-UP + Vinylester" bonded anchors made from electro-galvanized steel and stainless steel A4 (diameter M8 to M16) when subjected to centric tensile loads.

The "Friulsider Injection system KEM-UP + Vinylester" bonded anchors with the dimensions M24 to M30 are evaluated on the basis of the steel stress utilization level in relation to the stress cross section.

4.2.3 Proposed rating for the "Friulsider Injection system KEM-UP + Vinylester" bonded anchors (dimensions M8 to M30) in connection with anchor rods made from electro-galvanized steel (strength class ≥ 5.8)

Using the results achieved in the tests as a basis, fire resistance periods are proposed for the "Friulsider Injection system KEM-UP + Vinylester" bonded anchors (dimensions M8 to M30) made from electro-galvanized steel as shown in table 4-1 below as a function of the maximum centric tensile load.

Based on the results achieved in the tests, and departing from the evaluation specifications in TR 020 : 2004-05, the ratings for "Friulsider Injection system KEM-UP + Vinylester" bonded anchors made from electro-galvanized steel have been increased with regard to the 30-minute fire resistance time.

Table 4-1: Proposed rating for "Friulsider Injection system KEM-UP + Vinylester" bonded anchors (dimensions M8 – M30) made from electro-galvanized steel and stainless steel, regarding their fire resistance times as a function of stress σ_s when exposed to centric tensile loads

Designation	**"Friulsider Injection system KEM-UP + Vinylester" bonded anchor**						
Fire resistance time t_u [min]	**Maximum tensile load[1] F [kN]**						
	M8	**M10**	**M12**	**M16**	**M20**	**M24**	**M30**
Minimum set depth [mm]	80	90	110	125	175	210	280
30	1.64	2.60	3.35	6.25	9.75	14.04	18.26
60	1.12	1.77	2.59	4.82	7.52	10.84	14.10
90	0.59	0.94	1.82	3.40	5.30	7.64	9.94
120	0.33	0.52	1.44	2.69	4.19	6.04	7.86

[1] Loads resulting from European Technical Approval ETA-08/0383 may be decisive for the service condition.

4.2.4 Proposed rating for the "Friulsider Injection system KEM-UP + Vinylester" bonded anchors (dimensions M8 – M30) in connection with anchor rods made from stainless steel

Starting from the results achieved in the tests, the same characteristic tensile stresses (cf. table 4-1) are recommended for the "Friulsider Injection system KEM-UP + Vinylester" bonded

anchors, when adequate anchor rods made from stainless steel (material No. 1.4401 (A4) or 1.4571 (A5), 1.4529 /HCR) strength class 70) and nuts made from stainless steel (A4, strength class A-70) are used.

5 Annotations

5.1 This Test Report does not replace the attestation (General Building Code Test Certificate - abP; National Technical Approval - abZ, ETA) required under the German building code procedure. It should, in particular, be noted that the fire load density values of "Friulsider Injection system KEM-UP + Vinylester" bonded anchors can in the future be regulated by European Technical Approvals.

5.2 The above evaluation shall only apply to the tested "Friulsider Injection system KEM-UP + Vinylester" bonded anchors, due consideration being given to the boundary conditions shown in the technical annexes attached to this Test Report and/or the technical data sheets of Friulsider Spa.

5.3 The "Friulsider Injection system KEM-UP + Vinylester" bonded anchors may be used for anchoring applications in non-cracked reinforced concrete (strength class C20/25 as a minimum and C50/60 as a maximum) when primarily subjected to static loads.

5.4 The evaluation shall only apply in connection with members made from reinforced concrete, which can as a minimum be classified under the same fire resistance class as that of the anchors.

5.5 The validity of the Test Report will expire on 06/03/2013.

Materialprüfanstalt f. d. Bauwesen MPA 3.1 Braunschweig

ORR Dr.-Ing. Rohling
Head of Testing Laboratory

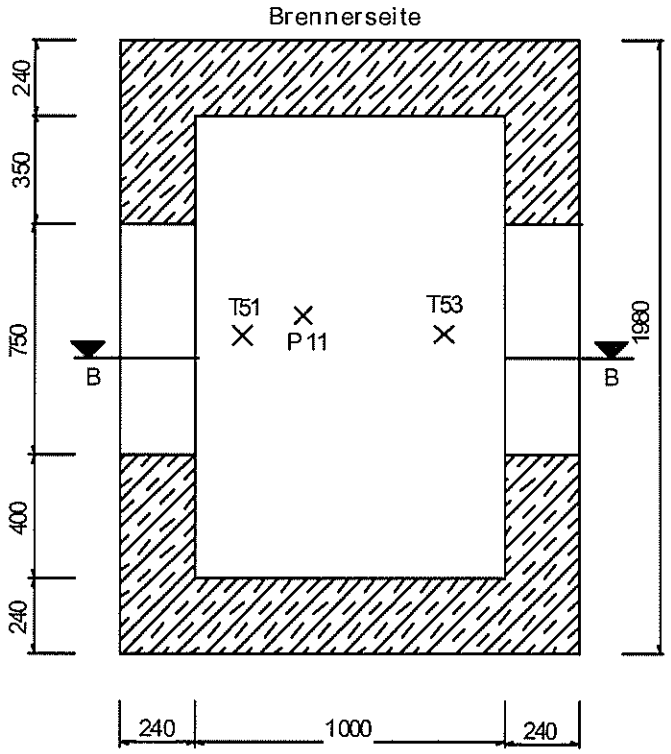
i.A. Bollmohr
Dipl.-Ing. Bollmohr
Engineer in charge

Braunschweig, dated 04 March 2009

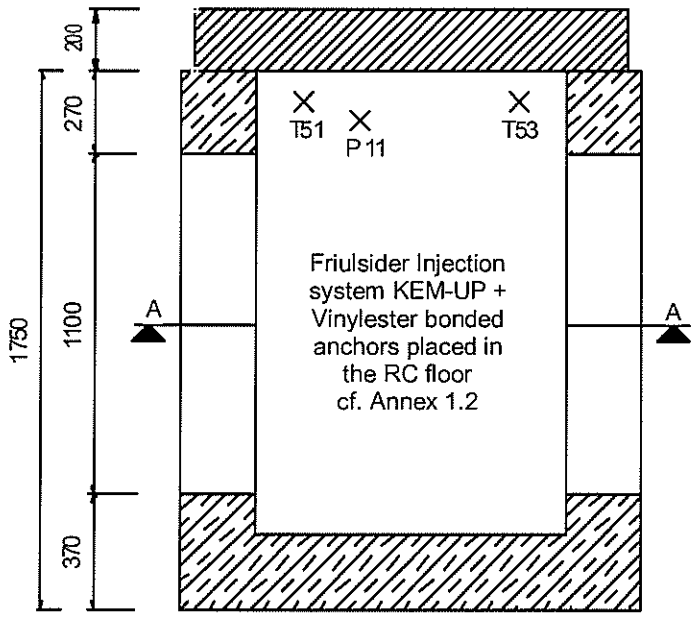
List of annexes

Furnace: chamber 6

Schnitt A-A



Schnitt B-B Deckenelement

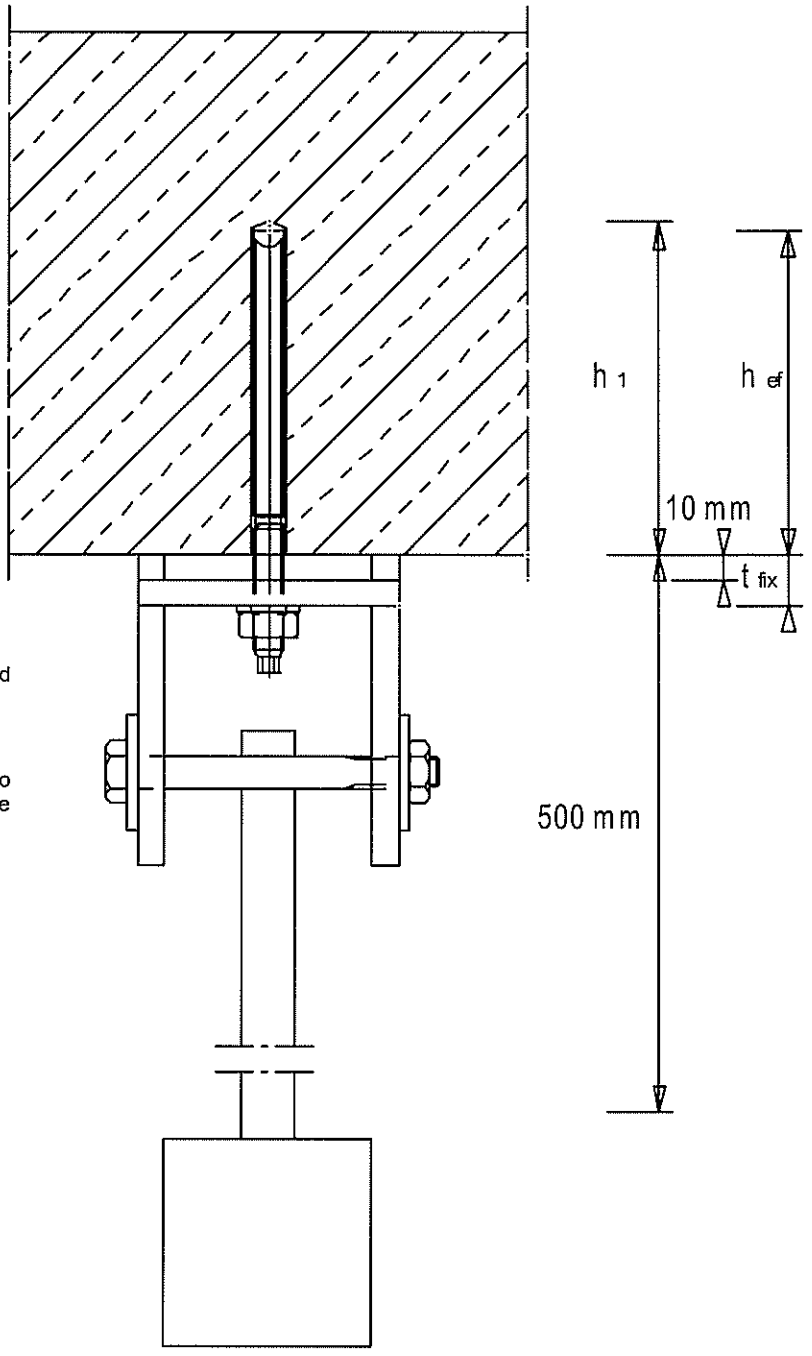


T51 and T53 measuring points of furnace temperature, thermocuples with measuring points made of Ni-Cr/Ni-Al-wires (type K)
P11 Pressure measuring head

Dimensions in mm

Structural design of specimen Illustration of test chamber	Annex 1.1 of Test Report No.: (3319/384/09)-NB dd. 04/03/2009
Materialprüfanstalt für das Bauwesen Institut für Baustoffe, Massivbau und Brandschutz der Technischen Universität Braunschweig	

"Friulsider Injection system KEM-UP + Vinylester" bonded anchors placed in
RC slab / d ≥ 200mm / 20/C25



Adapter: Steel adapter, genuine nut and washer

Suspender: Cr-Mo tension rod, 500mm w/o protection in the fire

Placed "Friulsider Injection system KEM-UP + Vinylester" bonded anchor
(in accordance with TR 020 : 2004-05)

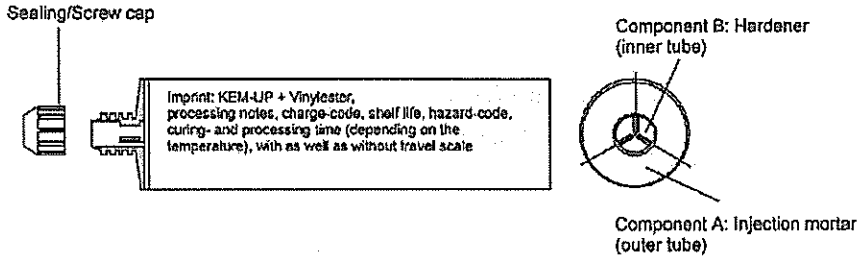
Annex 1.2 of
Test Report
No.: (3319/384/09)-NB
dd. 04/03/2009

Materialprüfanstalt für das Bauwesen
Institut für Baustoffe, Massivbau und Brandschutz
der Technischen Universität Braunschweig

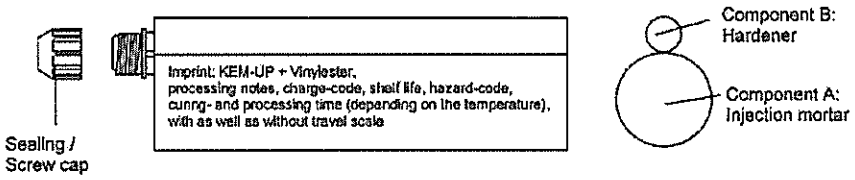
"Friulsider Injection system KEM-UP + Vinylester" bonded anchor

Cartridge: KEM-UP + Vinylester

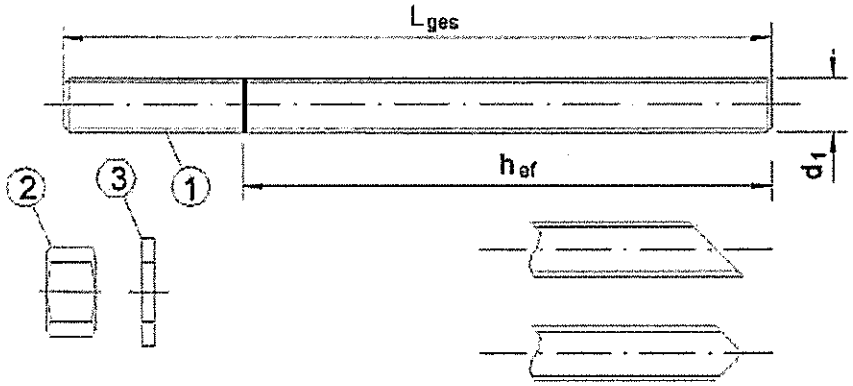
150 ml, 280 ml, 300 ml, 330 ml, 380 ml, 410 ml and 420 ml cartridge (Type: coaxial)



235 ml, 345 ml and 825 ml cartridge (Type: "side-by-side")



Static Mixer



Technical data "Friulsider Injection system KEM-UP + Vinylester" bonded anchor	Annex 1.3 of Test Report No.: (3319/384/09)-NB dd. 04/03/2009
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"Friulsider Injection system KEM-UP + Vinylester" bonded anchor

Part	Designation	Material
Steel, zinc plated ≥ 5 µm acc. to EN ISO 4042 or Steel, hot-dip galvanised ≥ 40 µm acc. to EN ISO 1461		
1	Anchor rod	Steel, EN 10087 or EN 10263 Property class 5.8, 8.8, EN ISO 898-1:1999
2	Hexagon nut, EN 24032	Property class 5 (for class 5.8 rod) EN 20898-2, Property class 8 (for class 8.8 rod) EN 20898-2
3	Washer, EN ISO 7089, EN ISO 7093, or EN ISO 7094	Steel, zinc plated
Stainless steel		
1	Anchor rod	Material 1.4401 / 1.4571, EN 10088-1:2005, > M24: Property class 50 EN ISO 3506 ≤ M24: Property class 70 EN ISO 3506
2	Hexagon nut, EN 24032	Material 1.4401 / 1.4571 EN 10088, > M24: Property class 50 (for class 50 rod) EN ISO 3506 ≤ M24: Property class 70 (for class 70 rod) EN ISO 3506
3	Washer, EN ISO 7089, EN ISO 7093, or EN ISO 7094	Material 1.4401 or 1.4571, EN 10088
High corrosion resistance steel		
1	Anchor rod	Material 1.4529 / 1.4565, EN 10088-1:2005, > M24: Property class 50 EN ISO 3506 ≤ M24: Property class 70 EN ISO 3506
2	Hexagon nut, EN 24032	Material 1.4529 / 1.4565 EN 10088, > M24: Property class 50 (for class 50 rod) EN ISO 3506 ≤ M24: Property class 70 (for class 70 rod) EN ISO 3506
3	Washer, EN ISO 7089, EN ISO 7093, or EN ISO 7094	Material 1.4529 / 1.4565, EN 10088

Commercial standard rod with:
- Materials, dimensions and mechanical properties acc. Table 1a
- Inspection certificate acc. to EN 10204:2004
- Marking of embedment depth

"Friulsider Injection system KEM-UP + Vinylester" bonded anchor

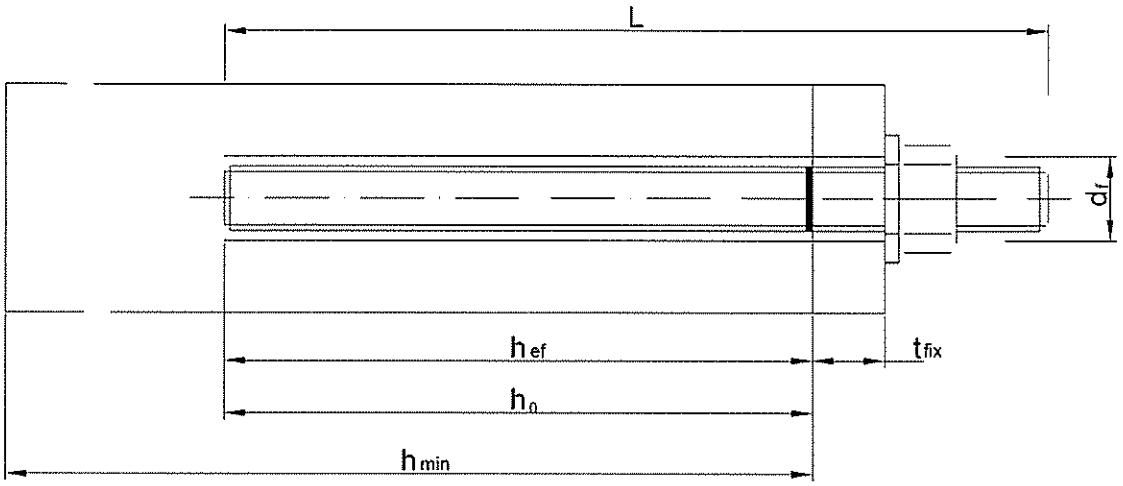
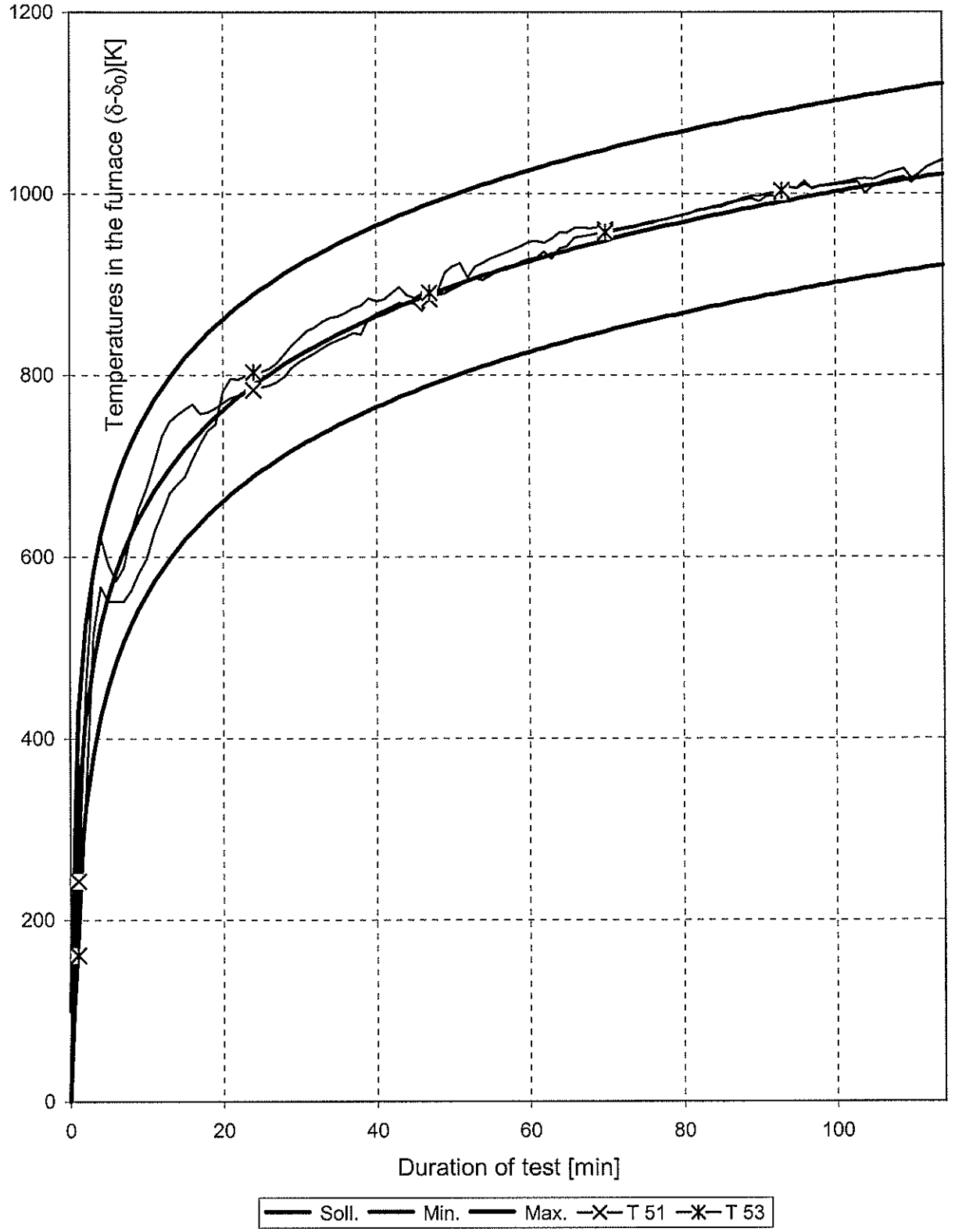


Table: Installation details "Friulsider Injection system KEM-UP + Vinylester" bonded anchor

Anchor size		M8	M10	M12	M16	M20	M24	M30
Norminal drill diameter	d_f [mm] =	10	12	14	18	24	28	35
Drill bit diameter	d_{cut} [mm] =		12.5	14.5	18.5	24.5	28.5	35.5
Depth of borehole	h_0 [mm] =	80	90	110	125	175	210	280
Through hole in connected member	d_f [mm] ≤	9	12	14	18	22	26	33
Steel brush diameter	d_b [mm] =	12	14	16	20	26	30	37
Torque	T_{inst} [Nm] =	10	20	40	80	120	160	200
Min. member thickness	h_{min} [mm]	110	120	140	160	215	260	340

ETK DIN EN 1363-1

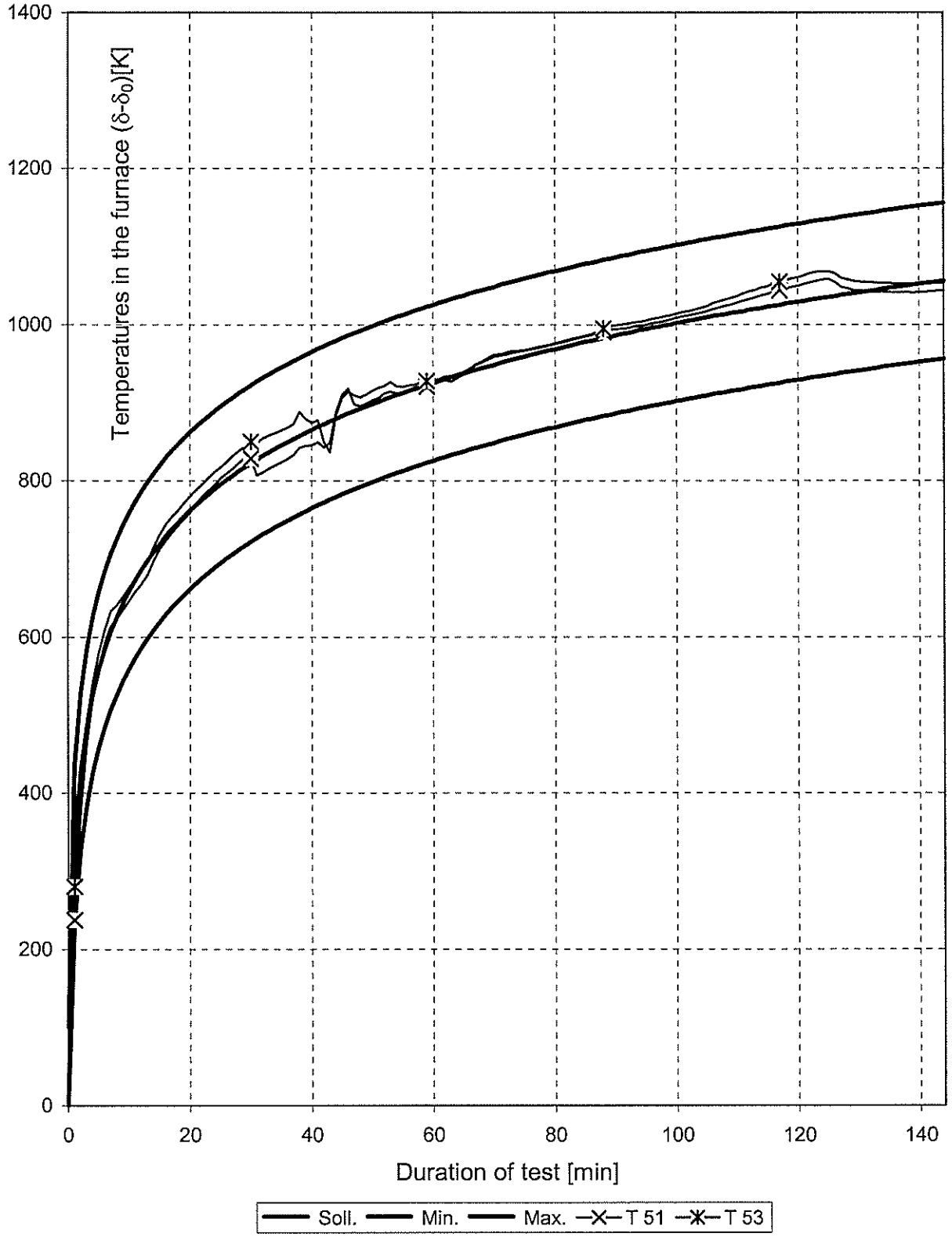


δ_0 = 16 °C

test date: 21.11.06

Temperatures in the furnace test 1	Annex 2.1 of Test Report No.: (3319/384/09)-NB
Materialprüfanstalt für das Bauwesen Institut für Baustoffe, Massivbau und Brandschutz der Technischen Universität Braunschweig	

ETK DIN EN 1363-1

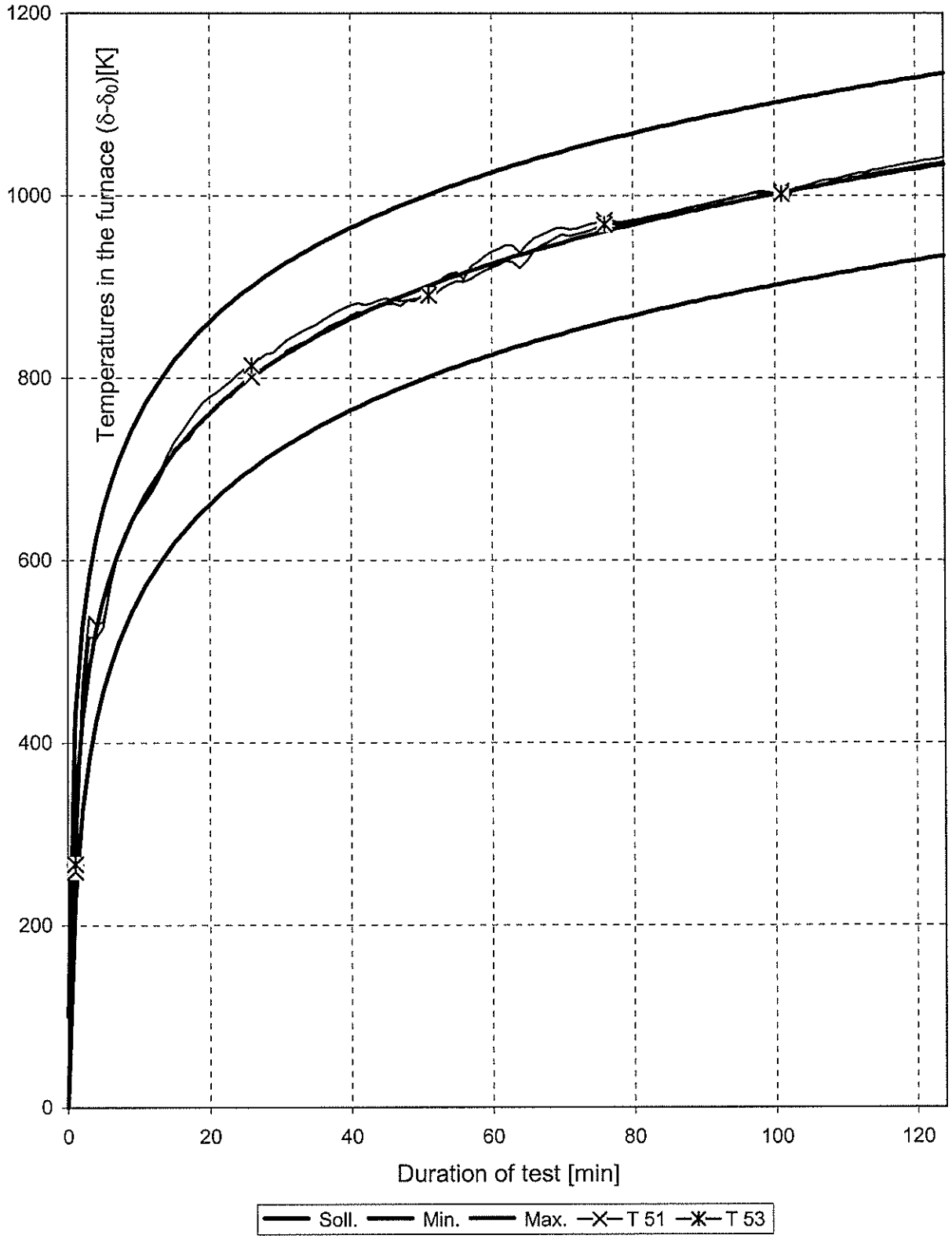


δ_0 = 17 °C

test date: 28.11.06

Temperatures in the furnace test 2	Annex 3.1 of Test Report No.: (3319/384/09)-NB
Materialprüfanstalt für das Bauwesen Institut für Baustoffe, Massivbau und Brandschutz der Technischen Universität Braunschweig	

ETK DIN EN 1363-1

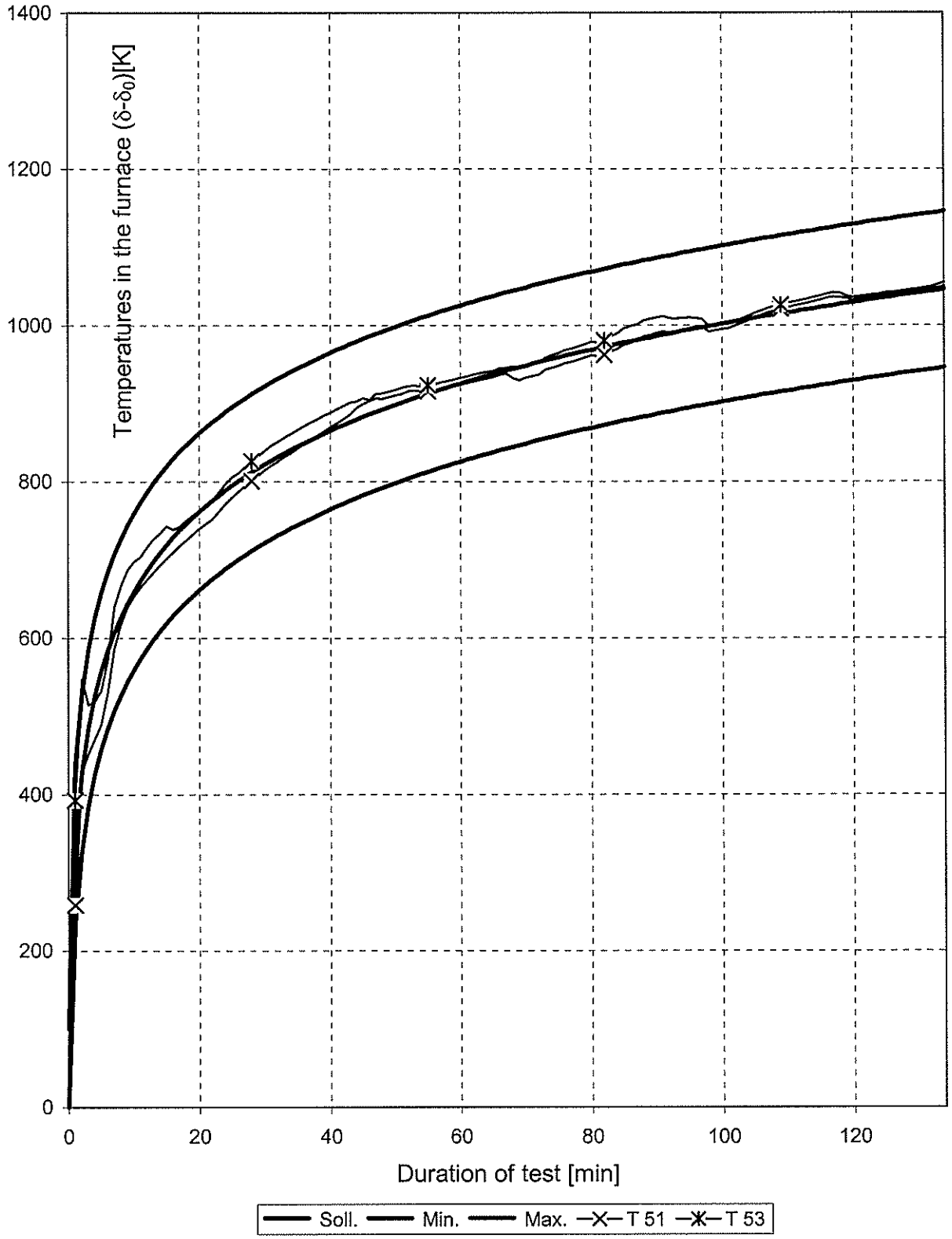


δ_0 = 18 °C

test date: 06.12.06

Temperatures in the furnace test 3	Annex 4.1 of Test Report No.: (3319/384/09)-NB
Materialprüfanstalt für das Bauwesen Institut für Baustoffe, Massivbau und Brandschutz der Technischen Universität Braunschweig	

ETK DIN EN 1363-1

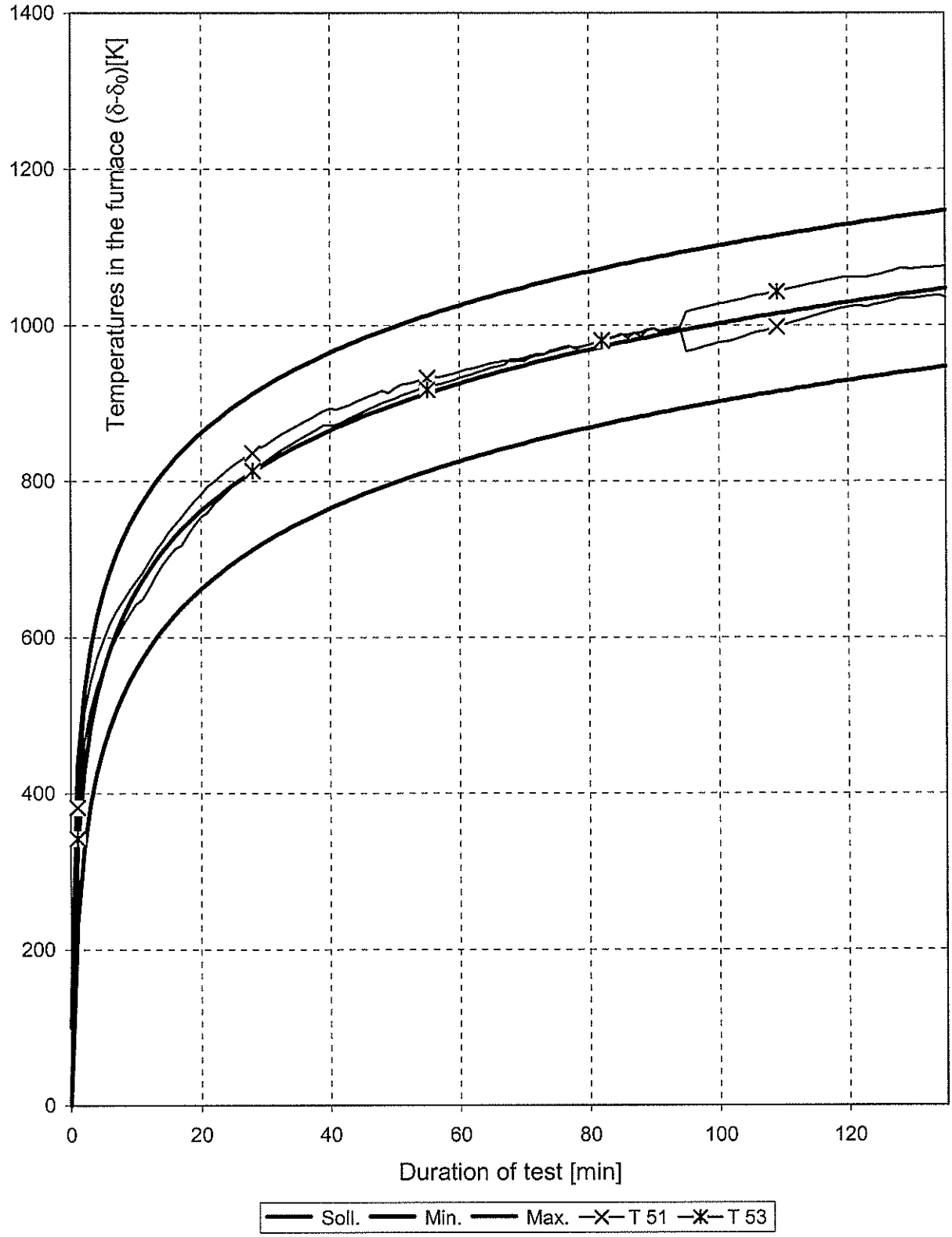


δ_0 = 18 °C

test date: 24.01.07

Temperatures in the furnace test 4	Annex 5.1 of Test Report No.: (3319/384/09)-NB
Materialprüfanstalt für das Bauwesen Institut für Baustoffe, Massivbau und Brandschutz der Technischen Universität Braunschweig	

ETK DIN EN 1363-1



δ_0 = 19 °C

test date: 20.02.07

Temperatures in the furnace test 5	Annex 6.1 of Test Report No.: (3319/384/09)-NB
Materialprüfanstalt für das Bauwesen Institut für Baustoffe, Massivbau und Brandschutz der Technischen Universität Braunschweig	

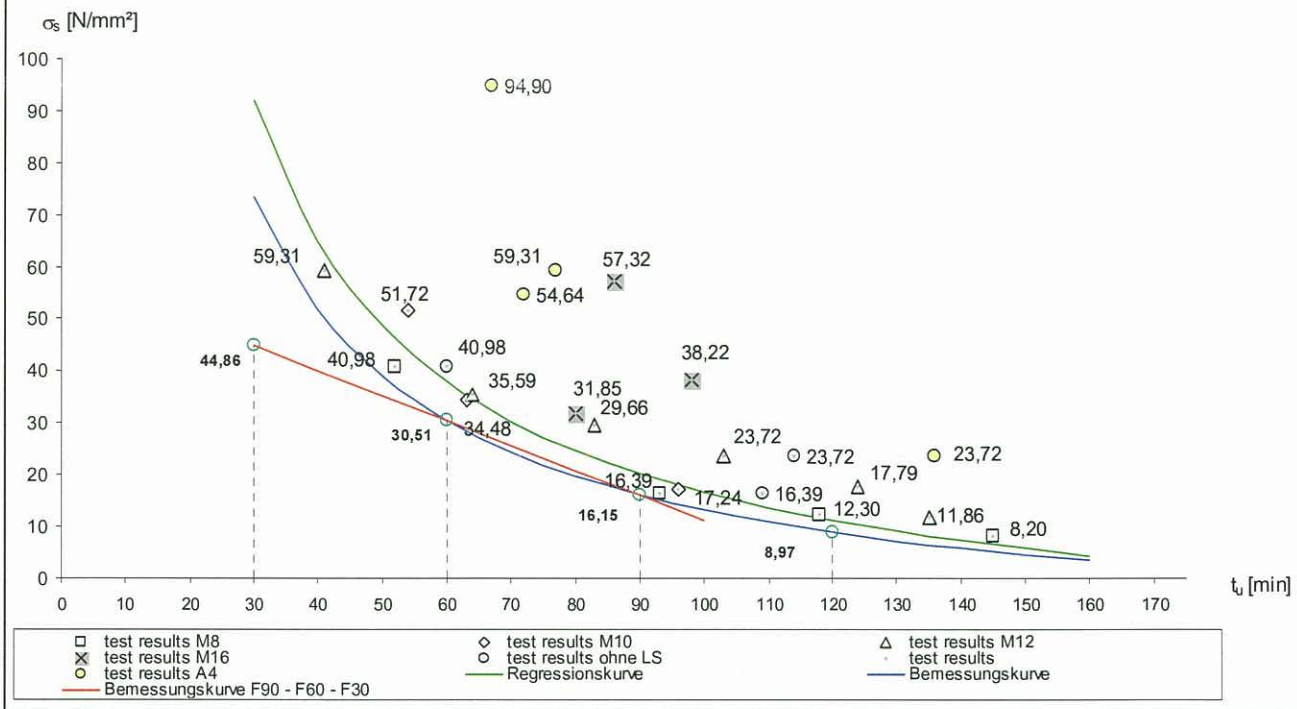


Fig. 1: Evaluation M8 to M10

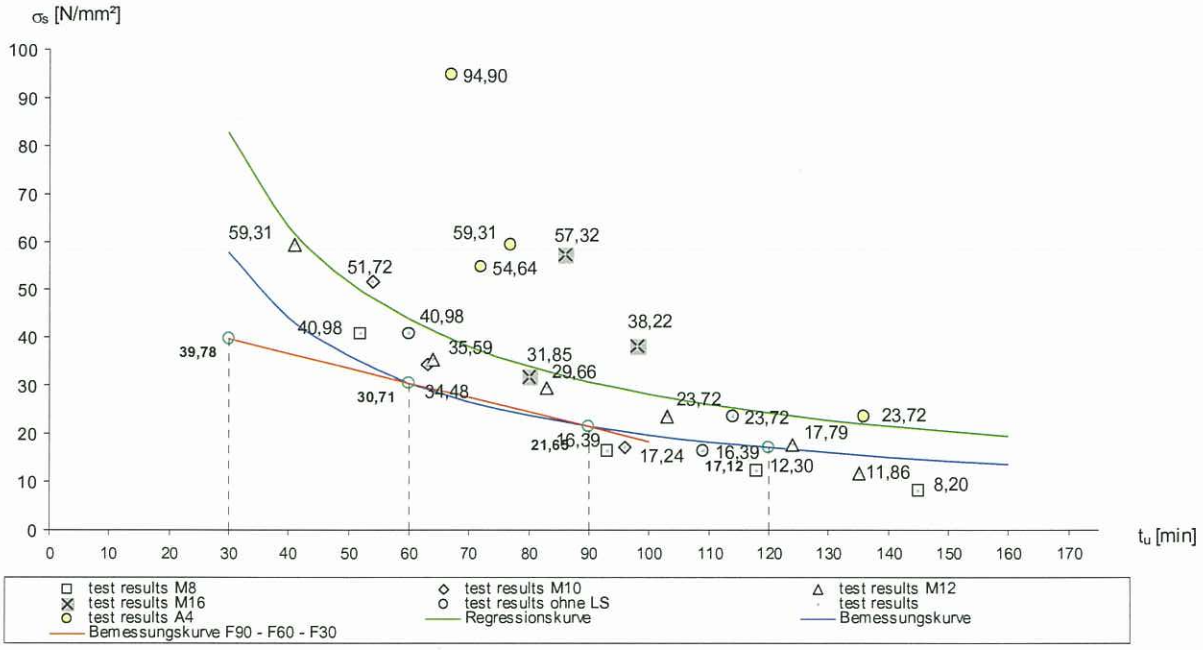


Fig. 2: Evaluation M12 to M30

Evaluation of test results "Friulsider Injection system KEM-UP + Vinylester" bonded anchor	Annex 7.1 of Test Report No.: (3319/384/09)-NB dd. 04/03/2009
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