Powers
FASTENERS
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December 22, 2009

Dear Powers Adhesive Anchoring Customer,

Powers has some GREAT NEWS regarding AC100+ GOLD low temperature installations!

We have some very important news to share with you. AC100+ Gold Adhesive shows no discernable load reduction at 23° F (-5° C) as tested by an ICC-ES accredited lab. We are also providing information for the use of AC100+ Gold down to 0° F (-18° C) with a 17% reduction in ultimate tension loads versus room temperature ultimate loads.

Many of you are aware that Powers Fasteners Inc. supports independent research to investigate the effects of environmental and installation conditions upon the short term and long term performance of anchoring adhesives. One of these projects has been the investigation of the effect of low temperature curing conditions on the bond strength of "acrylic" anchoring adhesives. Independent laboratory data, our internal laboratory results, and published information all demonstrate that many acrylic adhesives exhibit reductions of ultimate bond strength at reduced curing temperatures.
The industry has been made aware of testing that shows:

Some competitive manufacturers' adhesives lose up to 40% of their ultimate loads when installed in temperatures and base materials below 32° F.

In spite of knowing this, some manufacturers have stated that their adhesives perform satisfactorily down to zero degrees, without providing adequate guidance that load reductions at colder temperatures will occur. Some of these same manufacturers have no valid ICC-ES report for their acrylic adhesive. Powers has a current ICC-ES report on AC100+Gold (ESR-2582) with temperature validation. We will update the ESR report shortly with lower, qualified usage temperatures…please read below.

Attached please find two laboratory reports: First a report by IEA (an ICC-ES qualified laboratory) dated November 5, 2009 on Powers **AC100+ Gold** which confirms there is:

No load reduction under AC308 testing at 32° F and 23° F!

In light of the November 2009 low temperature use qualification testing, Powers has added a supplemental incoming quality control check and test for each batch of product to ensure ongoing performance in these conditions. In addition, AC100+ Gold adhesive cartridges produced after November 2009 utilize an updated lot code designation starting with the letter 'C' that denotes this additional quality control measure. For earlier production product which does not include the updated lot code designation, consideration and use of the product below 32° F should be substantiated by an additional test (e.g. such as a job site test) to the satisfaction of the Authority Having Jurisdiction (AHJ).

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Second, please find a Powers Laboratory test report of AC100+ Gold at 0° F (-18° C) showing the adhesive achieving 83% of its ultimate tension load at 70° F in 4,000 psi concrete (reduction can also be applied conservatively to shear loads).

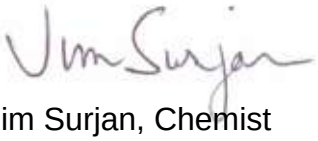
Distributors, users and specifiers should be aware and concerned if the adhesive anchor performance cannot be assured at the temperature in which is it installed and cured.

Regardless of what the competition says about the low temperature performance of their adhesives, please ask them to share their test results with you. Please also ask them for a copy of their ICC-ES report. As of this date, they won't be able to show you one that is current*.

As you may already know, Powers and Hilti* are the only two companies with an ICC-ES listed acrylic adhesives, tested to the 2006 IBC, and a valid ICC-ES report.

Other acrylic adhesives (such as A-7**, Acrylic Tie***, etc.) do not have a current ICC-ES report validating that they meet the 2006 IBC which has been adopted in all states. If a specifier or contractor is using one of these products, you should make them aware of the Powers ICC-ES report. Attached please find a state listing of code adoptions for the United States, a copy of our ICC-ES report, the IEA report and the Powers lab report.

Sincerely,



Jim Surjan, Chemist
Director of Adhesive Anchoring

* Except Hilti; Hilti is a registered trademark of Hilti Corporation
** A7 is a registered trademark of Illinois Tool Works
*** Acrylic-Tie is a registered trademark of Simpson Strong Tie Company

This information supersedes the previous announcement letter dated November 6, 2009.

TEST LABORATORY

Test Report No:	**AC100+Gold-0deg**
Test Date(s):	**9/25/09**
Test Description:	**Uncracked - Low psi**
Series No:	**Tension**

Product Information

Product Name:	**AC100+ Gold**	
Diameter:	**1/2"**	**in.**
Length:	**5**	**in.**
Cat. Code No:	**n/a**	
Lot Number:	**n/a**	
Manufactured by:		
Material type:	**Carbon steel**	
Material grade:	**B7**	
Coating:	**Zinc**	
Notes:		

Installation Information

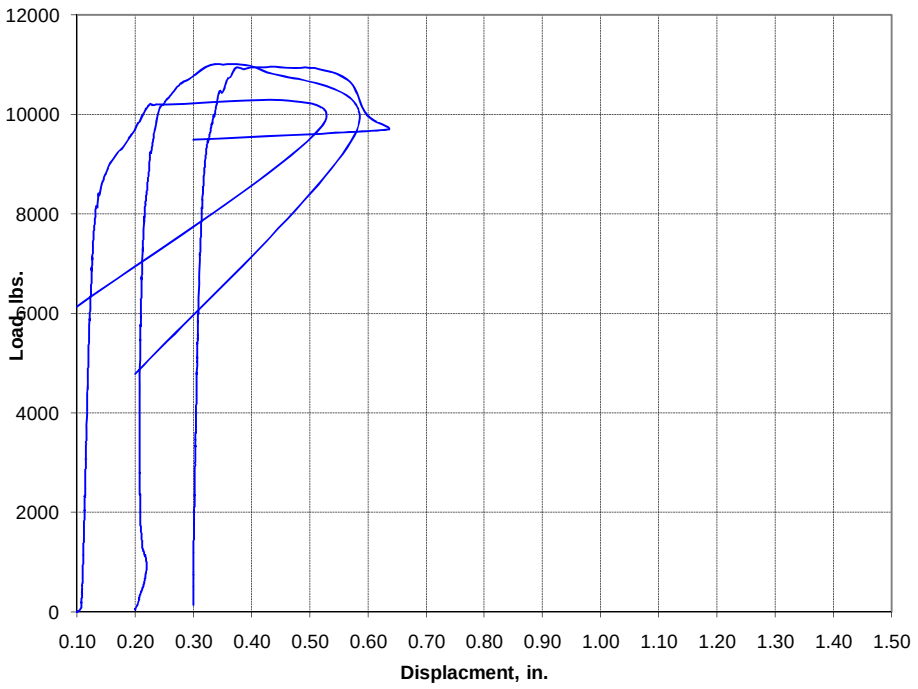
Nom. Embed.:	**2 1/2**	**in.**
Effect. Embed.:	**2 1/2**	**in.**
Install. Torque:		**ft-lbs.**
Notes:		
Nominal bit size:	**9/16"**	**in.**
Bit range:	**0.582 - 0.592**	**in.**
Actual bit size:	**0.588**	**in.**

Concrete Information

Concrete ID No.:	**4M09**	
Nominal strength	**4105**	**psi**
Tested Surface:	**Bottom**	
Notes:		

Test Equipment

Load cell ID	**50 Kip Cell**
LVDT ID	**1" travel**
Notes:	
Performed by:	**W Rivera**
Notes:	



Test Results

No.	Date	Actual Concrete, psi	B	T	Crack at Ult., in.	Disp. at Ult., in.	Ultimate Load, lbs.	Normal. Ult., lbs.	Failure Mode
1	9/25/09	4105			0.0000	0.121	10205	10205	Pull-out
2	9/25/09	4105			0.0000	0.131	11000	11000	Pull-out
3	9/25/09	4105			0.0000	0.117	10956	10956	Pull-out
4									
5									
6									
7									
8									
9									
10									
	AVERAGES:		**#DIV/0!**	**####**	**0.0000**	**0.123**	**10720**	**10720**	

Average Ult.:

10,720 lbs.

Sample COV:

4.2 %

Notes:

Norm. Ult.	**10,720**	lbs.
Sample S.D.:	**447**	lbs.
Number of tests:	**3**	
K for 5% fractal	**5.031**	
5% Load:	**8,473**	lbs.
k, 5%	**33.5**	
k, m	**47.5**	
Published value		lbs.
% of Published		

TEST LABORATORY

Test Report No:	**AC100+Gold-70Deg**
Test Date(s):	**9/29/09**
Test Description:	**Uncracked - Low psi**
Series No:	**Tension**

Product Information

Product Name:	**AC100+ Gold**	
Diameter:	**1/2"**	**in.**
Length:	**5**	**in.**
Cat. Code No:	**n/a**	
Lot Number:	**n/a**	
Manufactured by:		
Material type:	**Carbon steel**	
Material grade:	**B7**	
Coating:	**Zinc**	
Notes:		

Installation Information

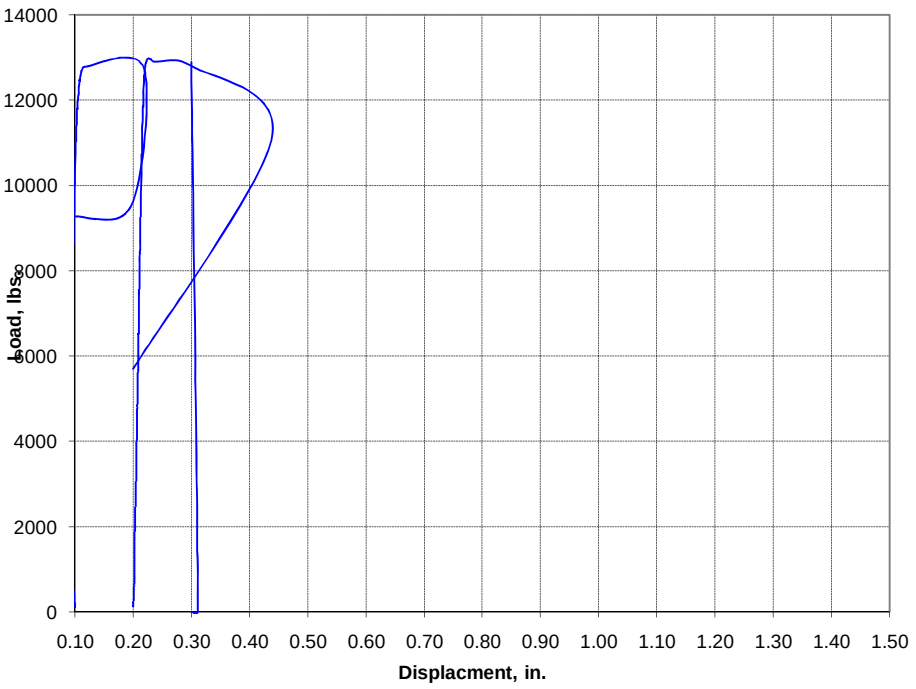
Nom. Embed.:	**2 1/2**	**in.**
Effect. Embed.:	**2 1/2**	**in.**
Install. Torque:		**ft-lbs.**
Notes:		
Nominal bit size:	**9/16"**	**in.**
Bit range:	**0.582 - 0.592**	**in.**
Actual bit size:	**0.587**	**in.**

Concrete Information

Concrete ID No.:	**4M08**	
Nominal strength	**4114**	**psi**
Tested Surface:	**Bottom**	
Notes:		

Test Equipment

Load cell ID	**50 Kip Cell**
LVDT ID	**1" travel**
Notes:	
Performed by:	**W Rivera**
Notes:	



Test Results

No.	Date	Actual Concrete, psi	B	T	Crack at Ult., in.	Disp. at Ult., in.	Ultimate Load, lbs.	Normal. Ult., lbs.	Failure Mode
1	9/29/09	4114			0.0000	0.013	12776	12776	Pull-out
2	9/29/09	4114			0.0000	0.026	12985	12985	Pull-out
3	9/29/09	4114			0.0000	0.011	12890	12890	Pull-out
4									
5									
6									
7									
8									
9									
10									
	AVERAGES:		**#DIV/0!**	**####**	**0.0000**	**0.017**	**12884**	**12884**	

Average Ult.:

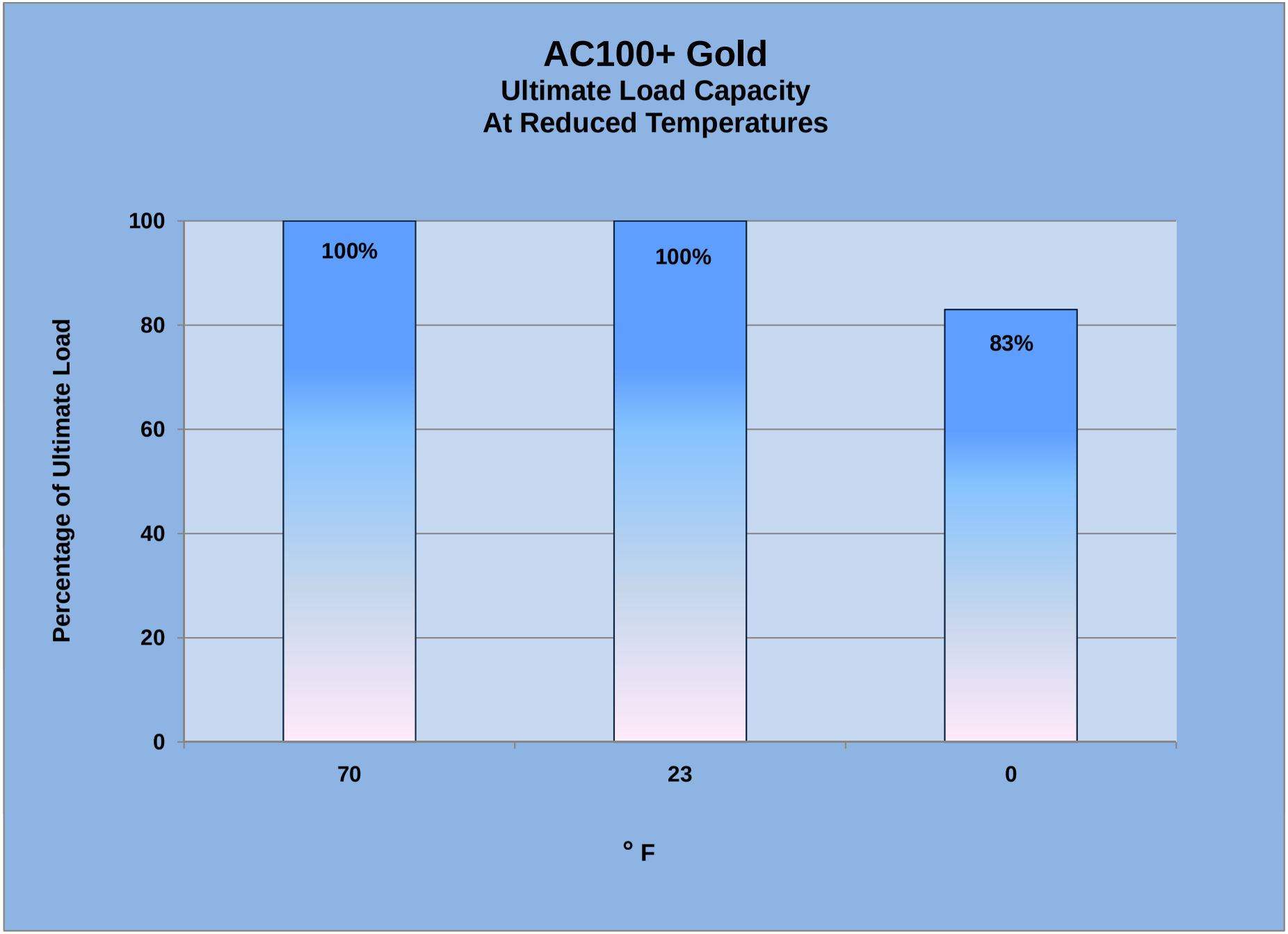
12,884 lbs.

Sample COV:

0.8 %

Notes:

Norm. Ult.	**12,884**	lbs.
Sample S.D.:	**105**	lbs.
Number of tests:	**3**	
K for 5% fractal	**5.031**	
5% Load:	**12,357**	lbs.
k, 5%	**48.7**	
k, m	**57.1**	
Published value		lbs.
% of Published		


AC100+ Gold
Ultimate Load Capacity
At Reduced Temperatures
Percentage of Ultimate Load
100
80
60
40
20
0
100%
100%
83%
70
23
0
° F

IEA

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Powers Fasteners, Inc.
Mr. Jeff Powers
Mr. Mark Ziegler
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Brewster NY 10509

Stuttgart, November 05, 2009

Powers AC100+ Gold Adhesive Anchor System for anchoring in concrete in accordance with AC308 - Minimum installation temperature -5°C (23°F)

Dear Jeff, dear Mark,

Company Powers wishes to establish -5°C (23°F) as minimum installation temperature for the Powers AC100+ Gold Adhesive Anchor System approved in [2]. The curing time shall be ≥ 14 hours. Therefore corresponding tests were conducted according to AC308 [5] at the test institute Bautest, which is accredited by IAS. The tests are described in [3]. The test conditions are summarized in Table 1. In all tests mortar cartridges were used which were sampled by an independent institute (IEA, sampled September 3, 2009)

No.	Series	Origin	Sampling/ testing date	Test lab	Inst. Temp.	Mortar Temp.	Curing Tempe.	Test Temp.	Curing time	N_{sust}/ τ_{sust}	size	Number of test
	[-]			[-]	°C	°C	°C	°C	h	kN/ N/mm²	[-]	[-]
1	Reference tests	[3]	Sept 3, 2009/ Oct. 14, 2009	BT	20	20	20	20	4	-	1/2"	5
2	Temp. -5°	[3]	Sept 3, 2009/ Oct. 14, 2009	BT	-5	5	-5	-5	14	-	1/2"	5
3	Temp. -5°, sustained load	[3]	Sept 3, 2009 Oct. 13-16, 2009	BT	-5	5	-5	23	14	32,0/10,6	1/2"	5

Table 1: Summary of the tests for the assessment of the behavior of bonded anchors Powers AC100+ Gold Adhesive Anchor System at decreased temperature.

All tests were performed in uncracked low strength concrete in test members produced from one concrete batch using a confined test set-up. The following test series were performed.

Tension tests without sustained loading

The anchors were installed and cured at decreased temperature (-5°C) (23°F). After curing over 14 hours the anchors were loaded to failure at -5°C (23°F).

Tension tests with sustained loading

In an additional test series the anchors were installed and cured at decreased temperature (-5°C) (23°F) with a curing time of 14 hours. Immediately thereafter, a constant tension load N_{sust} = 32.0 KN (τ_{Sust} = 10.6 N/mm²) was applied. Afterwards the temperature of the test chamber was increased at a constant rate to standard temperature (20^0 C) over a period of about 72 hours while monitoring the displacement response for each anchor. Once the test member had attained a temperature of about 20°C a confined tension was conducted.
According to AC308 a sustained load according to Equation (1) shall be applied to the anchor while the temperature is increased to 20°C.

$$N_{uts} = 0.55\, N_{o,\,l} \cdot (f_{c,test}/f_{c,test,i})^n \qquad (1)$$

with

$N_{o,\,l}$ = mean tension capacity as determined from reference service condition tests in low-strength concrete with wide support.
$f_{c,test}$ = concrete compressive strength as measured at the time of testing
$f_{c,test,i}$ = concrete compressive strength in the tests used to establish $N_{o,\,l}$
n = normalization exponent determined from results of tests in concrete with different strength and the failure mode pullout.

Equation (1) can be written in terms of bond strength values as follows:

$$\tau_{Sust} = 0.55\, \tau_{o,i} \cdot (f_{c,test}/f_{c,test,i})^n \qquad (2)$$

with

τ_{Sust} = bond stress generated by N_{Sust}
$\tau_{o,i}$ = mean bond strength evaluated from $N_{o,i}$

In [1] the mean bond strength of 1/2" threaded rods in concrete with f_c = 17 N/mm² measured in confined tests is $\tau_{o,i}$= 22.3 N/mm². The adjustment factor α_{setup} for conversion of failure loads measured in confined tests in uncracked concrete to unconfined tests is α_{setup} = 0.75 [5]. Therefore the bond strength valid for unconfined tests is $\tau_{o,i}$= 0.75 x 22.3 N/mm² = 16.7 N/mm². Furthermore a normalization exponent n = 0.13 is given in [1]. Based on the mean bond strength of 1/2" threaded rods in concrete with f_c = 17 N/mm² derived in [1] the required value τ_{Sust} is

$$\tau_{Sust} = 0.55 \cdot 16.7 \text{ N/mm}^2 \cdot (25.5/17.0)^{0.13} = 9.7 \text{ N/mm}^2$$

Based on the tests in [1] the applied sustained load was about 10% higher than required.

However the mean bond strength of 1/2" anchors in the reference tests is $\tau_{u,i,17}$= 26.1 N/mm² (see Table 2, line 1). This leads to a required sustained bond stress τ_{Sust} = 10.8 N/mm². The bond stress applied during sustained load is τ_{Sust} = 10.6 N/mm². Therefore the applied sustained approximately agrees with the required value.

Reference tests

In concrete members of the same concrete batch direct reference tests at 20°C were conducted with anchors installed, cured and tested at 20°C (68°F).

The results of the tests are evaluated according to AC308 in Table 2.

Evaluation of results of tests ([3])

In the tests without sustained loading the requirements according to AC308 are fulfilled (see Table 2, line 2), because the mean bond strength of the tests conducted at -5°C is equal with the mean bond strength measured in the reference tests. In the tests with sustained loading the mean residual capacity is 7% smaller than the mean bond strength of the reference tests (see Table 2, line 3). However, the t-test shows that the bond strength values measured in the residual load tests and the reference tests are statistically not significantly different. In the calculation a coefficient of variation V ≈ 6% was assumed which is the mean value of the 3 test series The t-test demonstrates that the results of the 2 test series belong to one population. For all test series, the coefficient of variation of the failure loads is V ≤ 10%. Therefore according to [5] a comparison of the 5% fractiles may be omitted.

According to AC308 the displacements of the anchors under sustained load just prior to tension testing to failure shall stabilize to the degree that an assessment can be made that failure is unlikely to occur. The displacements as a function of time are shown in Figure 1. The displacements increase linearly with time. The maximum displacement at the end of the test with sustained load is 0.55 mm. It is much smaller than the mean displacement at loss of adhesion in the reference tests (0.94 mm). Therefore failure is unlikely to occur.

In summary the tests [3] fulfill the requirements according to AC308.

According to [6] the behavior of bonded anchors installed at low temperature and subjected to a sustained load may be inferior to the behavior of anchors installed at 20°C, because the degree of mortar hardening when installing the anchors at low temperature may be smaller than that of the anchors installed at ambient temperature (20^0 C, 68^0F). To investigate the hardening of the subject mortar the hardening degree and degree of cross linking respectively was investigated chemically for curing at -5°C after 6 hours, 24 hours and 3 days and curing at 23^0 C (73^0 F) after 4 hours (minimum curing time) and 3 days [4]. The hardening degree of the mortar cured at -5°C was 91% (6h), 93% (24h) and 95% (3 days). The hardening degree of the mortar cured at 23^0 C was 93% (4h) and 98 % (3 days). After the minimum curing time the hardening degree of the mortar in the tests at -5°C had reached about the same level as in the reference tests at 23°C. With increasing curing time the hardening degree increased, however, the increase was much slower at curing at -5^0 C than at curing at ambient temperature. This could be expected because chemical reactions slow down with decreased temperature. However, the authors expect that the degree of hardening of the mortar cured at -5°C will increase to the same level as for mortars cured at 23^0 C over 3 days if the curing time is longer than 3 days or if the temperature of the base material increases. This assumption should be verified by corresponding tests in which the degree of curing is measured after curing at -5°C over 14 hours and heating the specimen to 20°C over 72 hours. In practice in general bonded anchors are not loaded with the allowable service load just after the minimum curing time has elapsed. Therefore the authors are of the opinion that the behavior of the Powers AC100+ Gold Adhesive Anchor System installed at low temperature (-5°C) under sustained load will be similar to the anchors evaluated in [1] and approved in [2] which were installed at 20°C and subjected to sustained tension load.

Summary

-5°C (23^0 F) is recommended as minimum installation temperature with a minimum curing time of 14 hours. The recommendation is valid only, if the anchors are installed according to the manufacturers written installation instructions. Furthermore it must be verified on site, that the temperature of the concrete in which the anchors will be installed is -5°C (23^0 F) or higher.

If you have any further questions, please contact us.

Prof. Dr.-Ing. R. Eligehausen

Dr.-Ing. J. Asmus

Literature

[1] Eligehausen R.: EVALUATION REPORT for the assessment of bonded anchors Chemofast Vinylester STVK/ ALVK for anchoring in concrete in accordance with AC308, Stuttgart, report dated 25.01.2008 (Note: The mortar STVK/ ALVK is identical with the mortar named Powers AC100+ Gold Adhesive Anchor System)

[2] ES-Report 2582, Powers AC100+ Gold Adhesive Anchor System in uncracked concrete, dated January 1, 2009

[3] Report No. A9069/2009 of company Bautest, Reference tests and tests at decreased temperature with Chemofast Vinylester STVK/ ALVK anchors according to AC 308, report in preparation

[4] Report No. G06-11-202/EH of University Erlangen, Lehrstuhl für Kunststofftechnik, Gutachterliche Stellungnahme zum Aushärteverhalten des. Injektionsmörtels 380 STVK Standard und Expressaktivität, Report dated 24.04.2007 (Remark: The mortar STVK/ ALVK is identity-inscal with the mortar named Powers AC100+ Gold Adhesive Anchor System)

[5] AC308, Acceptance Criteria for post-installed adhesive anchors in concrete elements. Approved June 2009, Effective July 1, 2009

[6] Hülder, G.: Zur Aushärtung kalthärtender Reaktionsharzsysteme für tragende Anwendungen im Bauwesen (Hardening of cold hardening resin systems for structural applications in civil engineering). Dissertation, Universität Erlangen-Nürnberg, 2008

	Series	Test lab	Inst. Temp.	Mortar Temp.	Curing Tempe.	Test Temp.	Curing time	N_{sust}/ τ_{sust}	size	h_{ef} [1]	$f_{c,cyl}$	Test member	n	F_{um} [2]	V [2]	Failure [3]	$\tau_{u,m}$ [4]	V [4]	$\tau_{u,17}$ [5]	$\tau_{k,17}$ [6]	$\tau_{u,17}$/ $\tau_{u,17,20°C}$	$\tau_{k,17}$/ $\tau_{k,17,20°C}$
	[-]	[-]	°C	°C	°C	°C	h	kN N/mm²	[-]	[mm]	[N/mm²]	[-]	[-]	[kN]	[%]	[-]	[N/mm²]	[%]	[N/mm²]	[N/mm²]	[-]	[-]
Reference tests at 21°C																						
1	Reference	BT	20	20	20	20	4	-	1/2"	74,6	25.5	180309A	5	81.7	4.1	$4*P,1*P_M$	27.5	4.5	2.,1	22.1	-	-
Temperature tests at -5°C																						
2	Temp. -5°	BT	-5	5	-5	-5	14	-	1/2"	75,0	25.5	180309A	5	82.0	8.6	5*P	27.4	8.0	26.0	18.9	1,00	(0,86) [7]
3	Temp. -5°, sustained load	BT	-5	5	-5	23	14	32,0/ 10,6	1/2"	75,6	25.5	180309A	5	76.8	5.6	5*P	25.5	4.8	24.2	20.2	0,93	(0,92) [7]

0) BT- independent accredited test lab company Bautest

1) Average embedment depth of the conducted tests

2) Measured average failure load and corresponding coefficient of variation

3) P= Pullout without mortar; P_M = Pullout with mortar;

4) Average bond strength and corresponding coefficient of variation calculated from the single failure loads and the measured embedment depth

5) $\tau_{u,17} = \tau_{u,m} \cdot (17/f_{c,cyl})^{0,13}$

6) Calculated assuming unknown standard deviation

7) Comparison of fractiles is not required according to AV308 because of the low scatter of test results (V < 10%).

Table 2: Evaluation of the results of tests [3] at decreased temperature, confined tests in non cracked concrete.

Test parameters	sustained load N_{sust}	32.0 kN	(loaded with spring pot)
	corresponding τ_{sust}	10.6 N/mm²	
	temperature	-5 – +23 ℃	
	nominal effective anchorage depth h_{ef}	76 mm	
	testing period:	13 - 16 Oct. 2009	

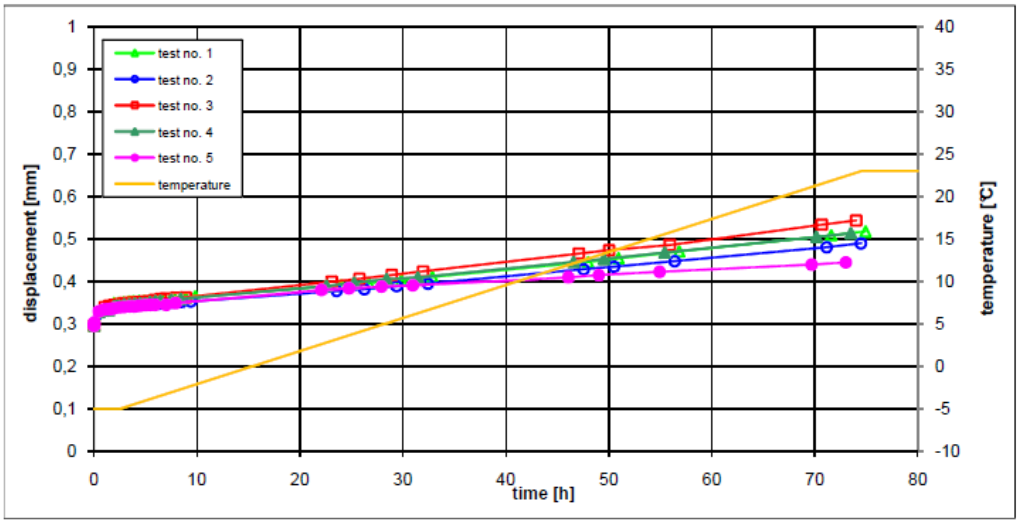

Figure 1: Displacements of anchors installed at ϑ = -5℃ loaded with a constant tension load (τ_{sust} = 10,6 N/mm²) and heated to 20℃ in linear-logarithmic scale, Powers AC100+ Gold Adhesive Anchor System, size ½", curing at -5℃ over 14 hours, tests according to [3]