Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

4DH
4th Generation District Heating Technologies and Systems

reINVEST

3RD INTERNATIONAL CONFERENCE ON

SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING

COPENHAGEN, 12–13 SEPTEMBER 2017

AALBORG UNIVERSITY
DENMARK

COST EFFECTIVE

4TH GENERATION

DISTRICT HEATING CONCEPTS

LAYING METHODS

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PRESENTATION AND BACK GROUND

- Kim Rolin
  - 1994 Diplom-Eng. in buildings.
  - 1994-2002 Contractor (JFE) - company specialized in DH-systems – civil- and pipework.
  - 2002 - Ramboll
  - 2002-2004 Worked together with Peter Randløv (Ramboll) Convenor of WG13 – (EN 13941)
  - 2003 - Expert-member of WG 13 and S 190 (Danish Mirror committee

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District heating arrives in Denmark …

Fjernvarmen kommer til Danmark

Med lidt god vilje kan man hævde, at verdens første fjernvarmeværk opstod i 1860'erne i København! I perioden 1863-1869 blev en bygning opført for Zoologisk Museum i Krystalgade, og den fik en (efter datidens forhold) meget avanceret opvarmningsform med damp. Ikke alene museet, men også en del andre bygninger omkring Frue Plads og Nørregade blev forsynet herfra via rør.[7]

Mange opfatter imidlertid Frederiksberg Forbrændingsanstalt, grundlagt i 1903 som det første fjernvarmeværk i Danmark. Årsagen til, at Frederiksberg var så tidlig ude, skal søges i, at kommunen allerede ved indgangen til det forrige århundrede var ved at være fuldt udbygget. I slutningen af 1800-tallet var Frederiksberg Kommune kommet i den situation, at losspladserne inden for kommunegrænsen var ved at være fyldt op. Man stod derfor over for valget om enten at erhverve nye lossepladser uden for kommunegrænsen eller at bygge et forbrændingsanlæg. De ledende kredse i Frederiksberg Kommune var imidlertid ikke stemt for at få lossepladser uden for kommunegrænsen

The first district heating plant in Denmark was finished in 1903 in the centre of Copenhagen for burning waste due to lack of landfilling space. The plant was at first just supplying the local poorhouse with steam.

The chimney and plant house is protected and now standing next to a modern 200MV peak load oil fired boiler plant.

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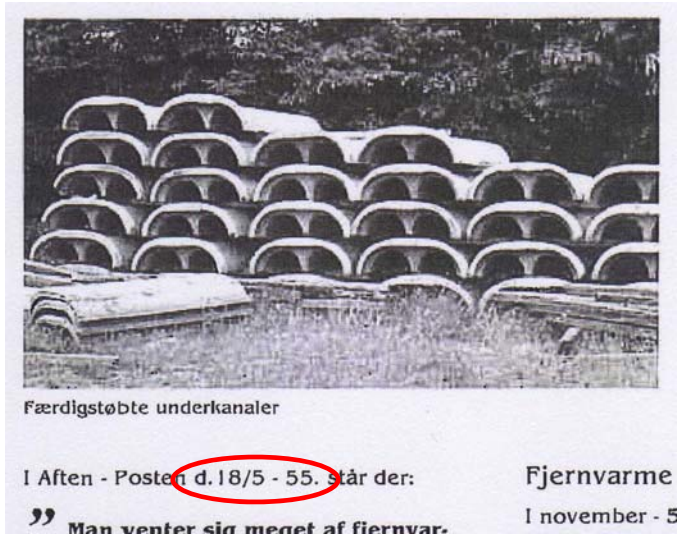
The way to modern DH systems …

It started with steam systems in the larger cities but after a couple of decades hot water systems came up.

At that time all systems were made with pipes in concrete ducts where pipe stress was eliminated with anchors and compensators or expansion loops.

Færdigstøbte overkanaler med cellebeton



Færdigstøbte underkanaler

In 1957 the Danish District heating Association was founded.

In 1959 something happened …

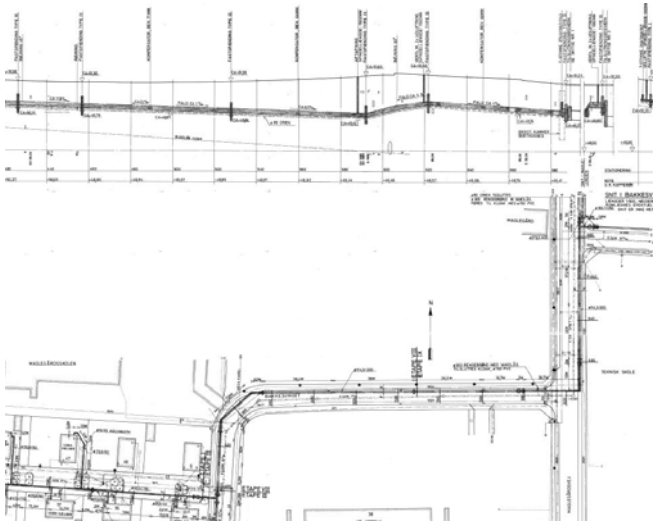
Ege Andersen

Mr. Ege Andersen, managing a plumbing and coppersmith company in the small city of Løgstør found in late 1950th a way to put a steel pipe in a casing pipe an insulate the space between the pipes with PU-foam.

The pre-insulated pipe was invented.

He founded a company called **LØGSTØR RØRindustri** today known as **LOGSTOR.**

In the 1960th and 1970th most pre-insulated pipe systems were still fully or partly compensated with no or low pipe stress constructed with either expansion loops or the “sliding” system where the steel pipe moved freely inside the insulation and with anchor blocks and compensators.
The “sliding” system was used up until the 1980th.



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In 1982 the first Danish standard for design and installation of district heating concrete and pre-insulated pipe systems was published.
3 Ramboll engineers participated in making the standard.

The Danish standard was the foundation for the EN standard 13941 we use today and Ramboll has always been represented in both the Danish and EN standard committees.

The purpose for making this standard has from the beginning been to make more efficient and reliably district heating systems.

The standard committee is working continuously to improve and include new discoveries and experience to make sure the standard always will represent best practise and be state of the art.

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Together with EN 13941 there is a numbers of associated standards which describe how **all** parts of a complete DH system must be made and to which quality.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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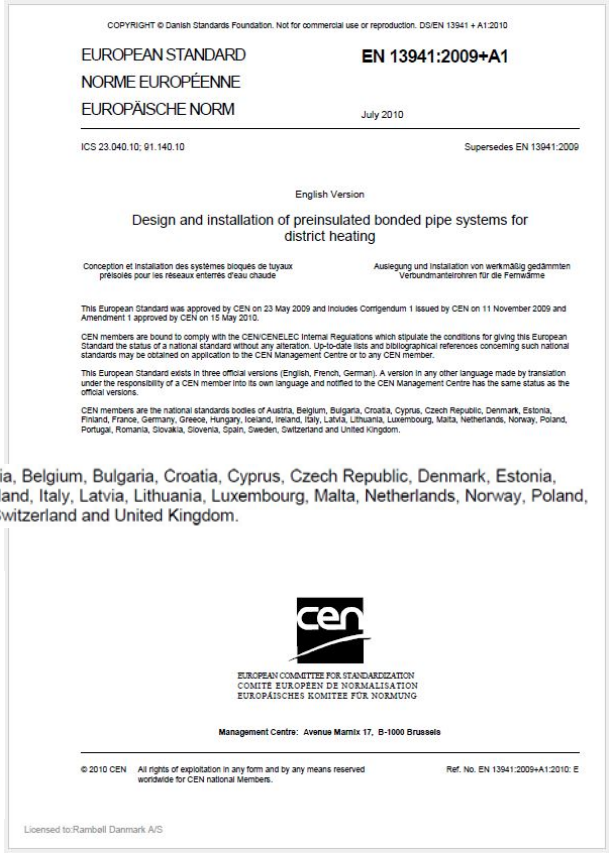

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 13941:2009+A1

July 2010

ICS 23.040.10; 91.140.10

Supersedes EN 13941:2009

English Version

Design and installation of preinsulated bonded pipe systems for district heating

Conception et installation des systèmes bloqués de tuyaux préisolés pour les réseaux enterrés d'eau chaude

Auslegung und Installation von werkmäßig gedämmten Verbundmantelrohren für die Fernwärme

This European Standard was approved by CEN on 23 May 2009 and includes Corrigendum 1 issued by CEN on 11 November 2009 and Amendment 1 approved by CEN on 15 May 2010.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 13941:2009+A1:2010: E

HISTORY OF STANDARDS SHORT

DK-Standard for DH:	1982 - (DS 448)
EN-standard for: DH-komponents	1990 – (EN 253 – max DN600)
EN- standard 13941: Design and installation	2003 (first version)
Current version	2010
New version expected	2018

DISTRICT HEATING LAYING METHODS

Compensated systems (reduction of axial forces)

- Pipe-systems preheated in open trench - sections made with Z-bends and U-bends
- Pipe-systems compensated with L,Z and U-bends without preheating or with preheating after backfilling of trench but with open trench at the bends.
- Pipe-systems with E-compensators (SUC=Single use compensator).

Cold-laying (High Axial Stress-systems):

- Pipesystems without preheating or compensations-elements as bends and SUC.

RUC – ROSKILDE UNIVERSITY CENTRE

Pipe network - The Danish way

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Benefits in design …

Lower temperature =

Longer expected lifetime

100 °C > 100 year

115 °C = 50 year

120 °C = 30 year

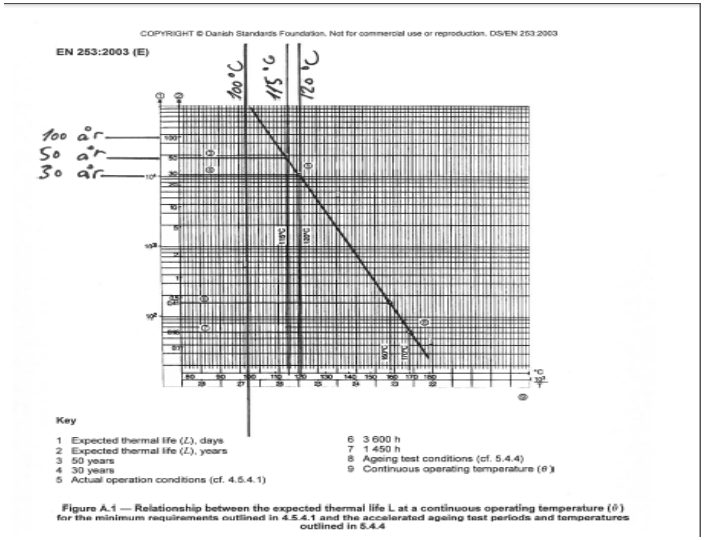
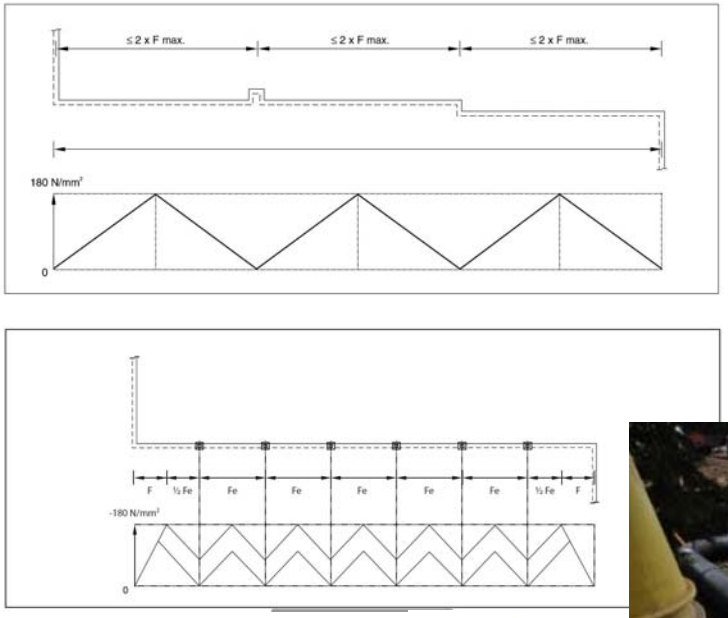


Figure A.1 — Relationship between the expected thermal life L at a continuous operating temperature (θ) for the minimum requirements outlined in 4.5.4.1 and the accelerated ageing test periods and temperatures outlined in 5.4.4

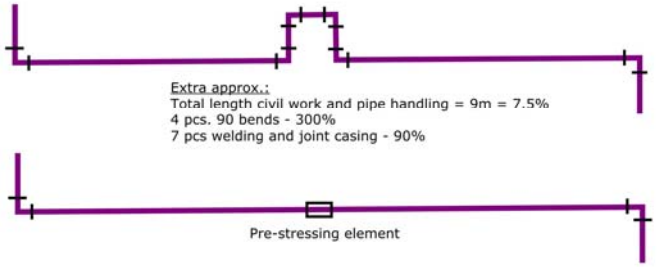
Benefits in design …



Expansion loops / Pre-stressing elements

Example: DN 100 / 4" series 2 – ø114,3/225

F (m) = 55 m x 2 = 110m
U = 2,1m – Due to pre-installing joints U≥3m



Extra approx.:
Total length civil work and pipe handling = 9m = 7.5%
4 pcs. 90 bends - 300%
7 pcs welding and joint casing - 90%

Pre-stressing element

Expansion loops is typically made on both supply and return.
Pre-stressing elements only on supply.

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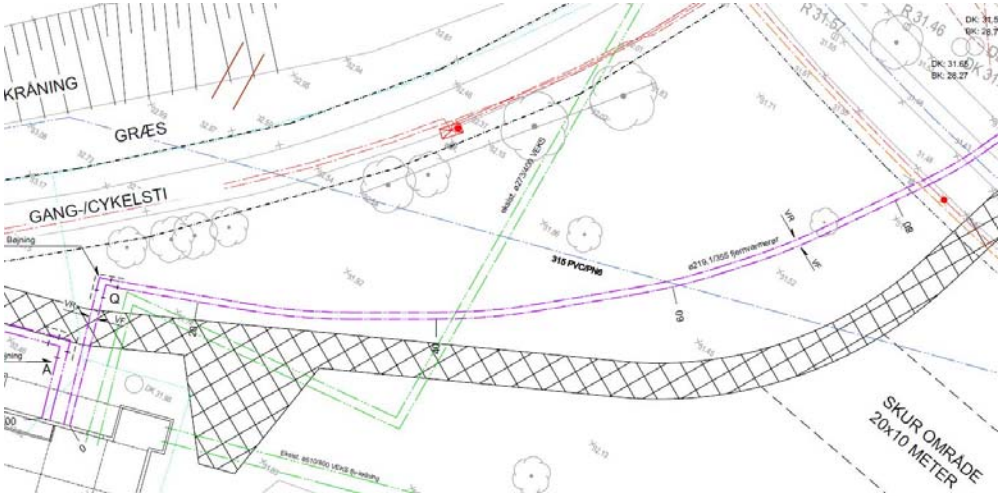
Benefits in design …



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FAST LAYING OF LONG SECTIONS

RENOVATING DN700/1000

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FAST LAYING OF LONG SECTIONS

RENOVATING DN700/1000

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FAST LAYING OF LONG SECTIONS

NEW TRANSMISSIONLINE DN250/450

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FAST LAYING OF LONG SECTIONS

NEW TRANSMISSIONLINE DN250/450

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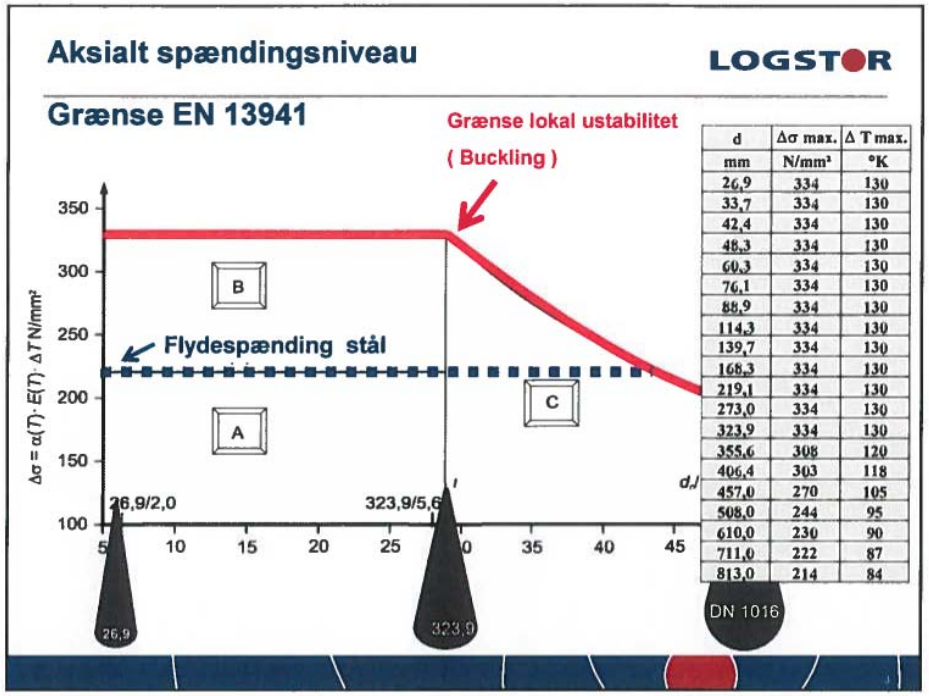
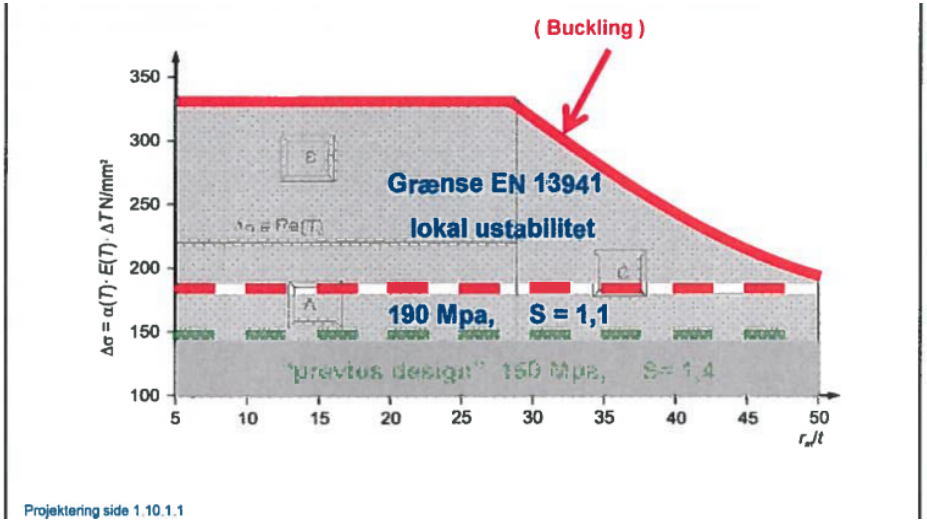


d	Δσ max.	Δ T max.
mm	N/mm²	°K
26,9	334	130
33,7	334	130
42,4	334	130
48,3	334	130
60,3	334	130
76,1	334	130
88,9	334	130
114,3	334	130
139,7	334	130
168,3	334	130
219,1	334	130
273,0	334	130
323,9	334	130
355,6	308	120
406,4	303	118
457,0	270	105
508,0	244	95
610,0	230	90
711,0	222	87
813,0	214	84


(Buckling)
Grænse EN 13941
lokal ustabilitet
190 Mpa, S = 1,1
"previus design" 150 Mpa, S= 1,4
Δσ = α(T)·E(T)·ΔT N/mm²
350
300
250
200
150
100
5
10
15
20
25
30
35
40
45
50
r_m/t
Projektering side 1.10.1.1

STRESSES OVER YIELD-STRESS

IS THAT POSSIBLE ? AND WHAT TO BE AWARE OF

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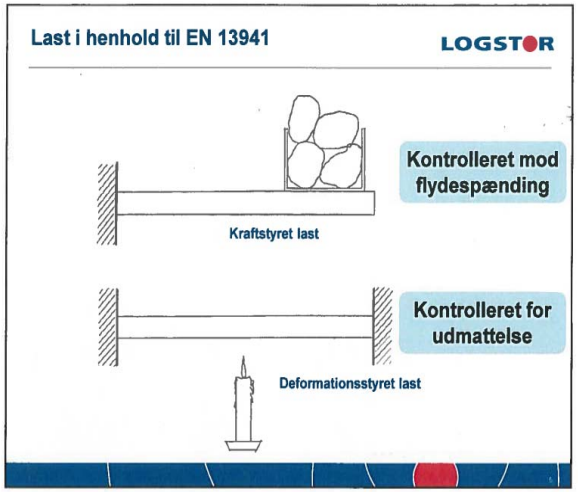
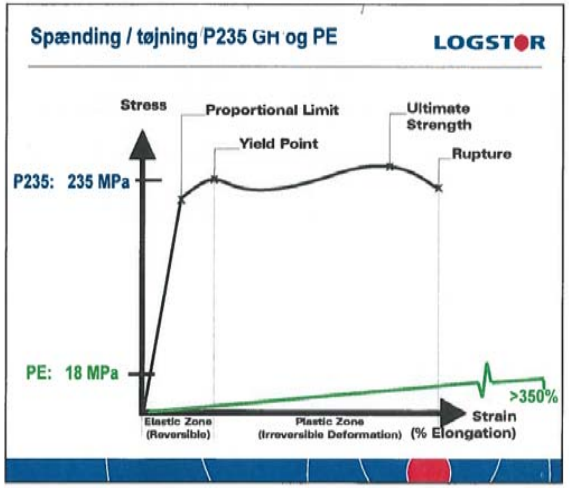
HIGH AXIAL STRESS
PRINCIPLES OF FORCES

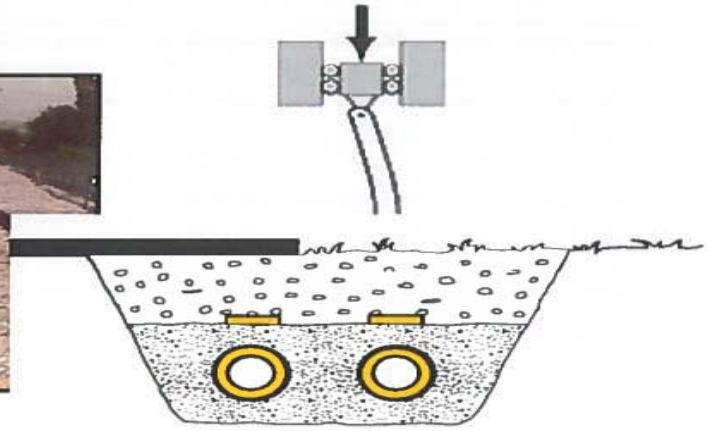




Aksialt spændingsniveau

LOGSTOR

Stabilitet - lokal / global



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TOPICS TO CONSIDER WHEN USING SYSTEMS WITH HIGH AXIAL STRESS.

- The risks of parallel excavations near DH-pipes (other utilities)
- Necessary soilcover when using curved pipes.
- Limitation in the use of angular deviations at welds.
- Reductions of pipes (only 1 dimension at a time)
- Special attention for branches, both prefabricated and “in-situ” – fatique are the main-topic.
- Larger deformations at the bends.

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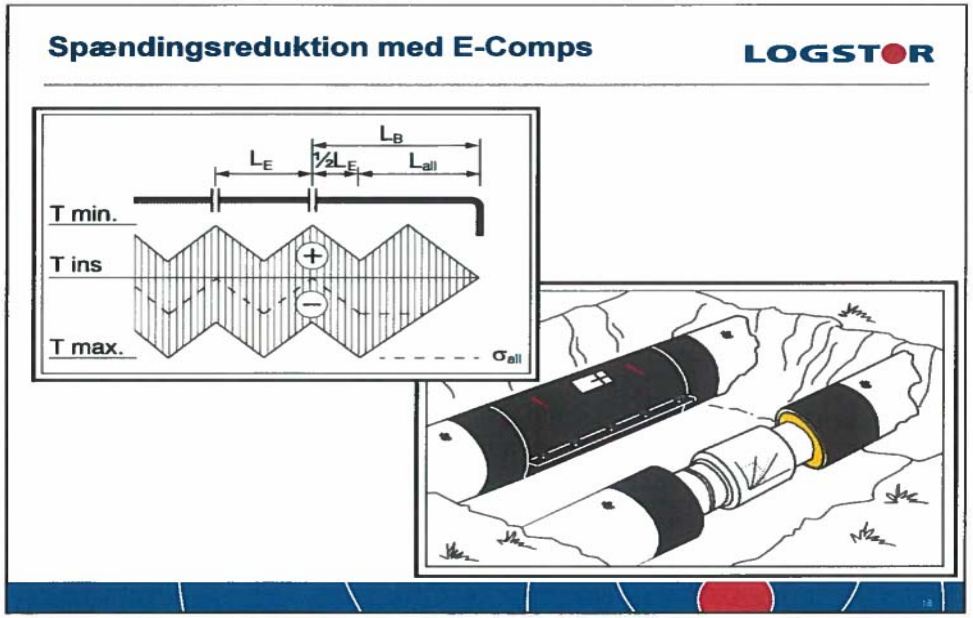
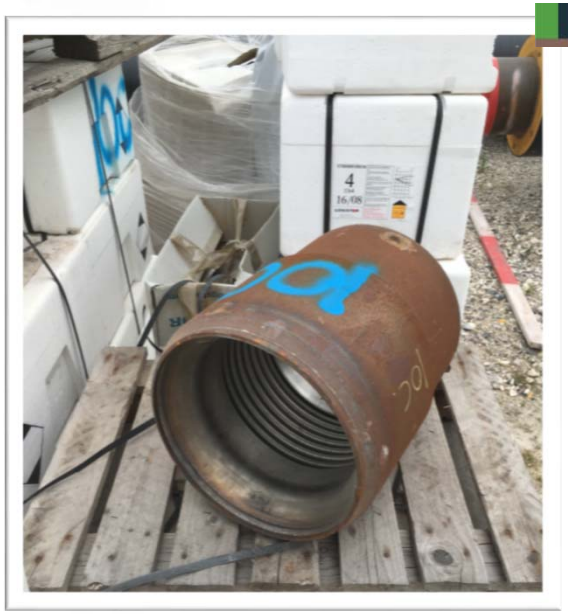
COST EFFECTIVE 4TH GENERATION DISTRICT HEATING PIPE CONCEPTS
12+13 SEPTEMBER 2017


2014/09/30 18:11

LOWERING THE STRESSES BY USING E-COMPENSATORS. (SUC)





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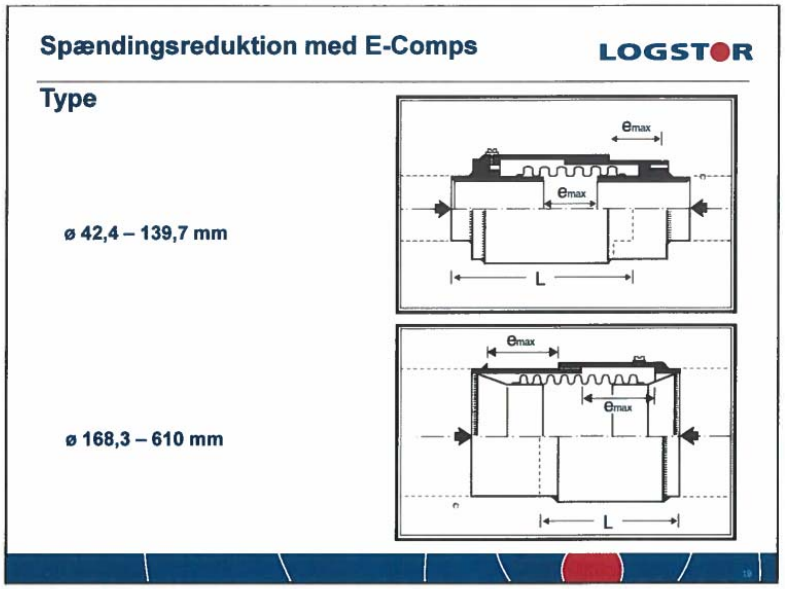
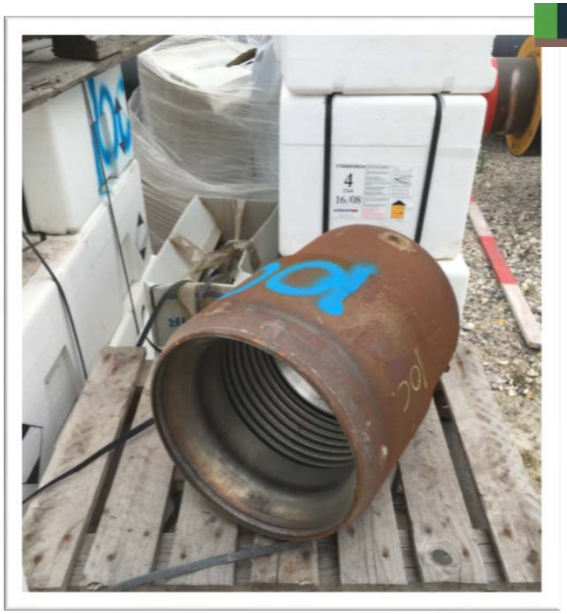
LOWERING THE STRESSES BY USING E-COMPENSATORS. (SUC)





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TOPICS TO CONSIDER WHEN USING E-COMPENSATORS.

How long are the periode from welding in the E-compensator to making the final “closing” of the E-compensator ?

Is it possible to come back for closing at the time of commissioning or shall the E-compensator be closed “before leaving working-area” ?

E-compensators must only be connected to straight pipes. Elastic bending on sections with E-kompensators are not alowed

Using of E-kompensators with preset gap or with “full gap”.

HOW TO HANDLE (LARGE) DEFORMATIONS AT THE BENDS

Sandcushions –	only suitable for open field an only for small deformations (recommended not to be used)
Foamcushion -	Maximum allowable deformation 70% of 120mm = 84mm (may require extra strong foam at bends)
“open bends” -	Area around bends are backfilled after “first-time” expansion. (reducing of deformation)
Special Constructions -	making space to allow pipes to expand without soilpressure.

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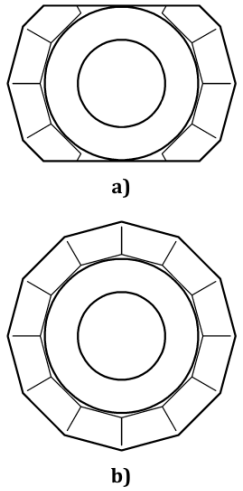
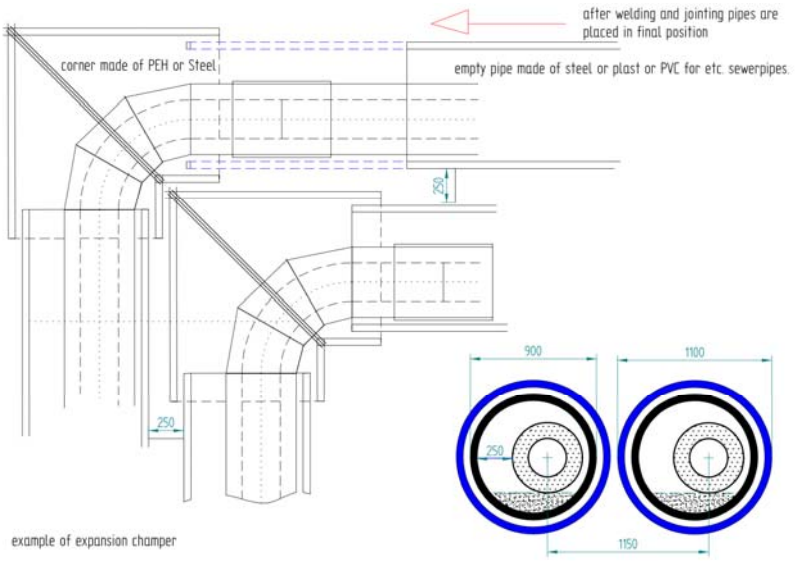
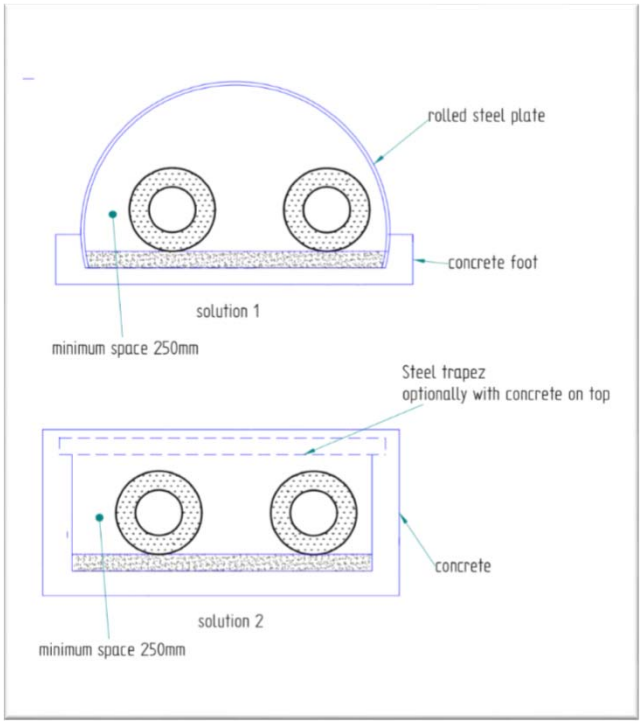


Figure 12 — Possibilities for expansion cushions of the outer casing



example of expansion champer



BENEFITS FROM USING E-COMPS OR HIGH AXIAL STRESS SYSTEMS ACC. EN 13941

- Reducing amount of weldings and joints significant, (and the risk of failures)
- Lowering the cost of components and pipework, welding/mounting.
- Lower cost of civil-works due to more simple routing, better workflow (no preheating) easier handling of the traffic (no U or Z-bends needed) and shorter construction time (shortening of the time with open trenches means less traffic-handling and maintenance of trences and working-area).

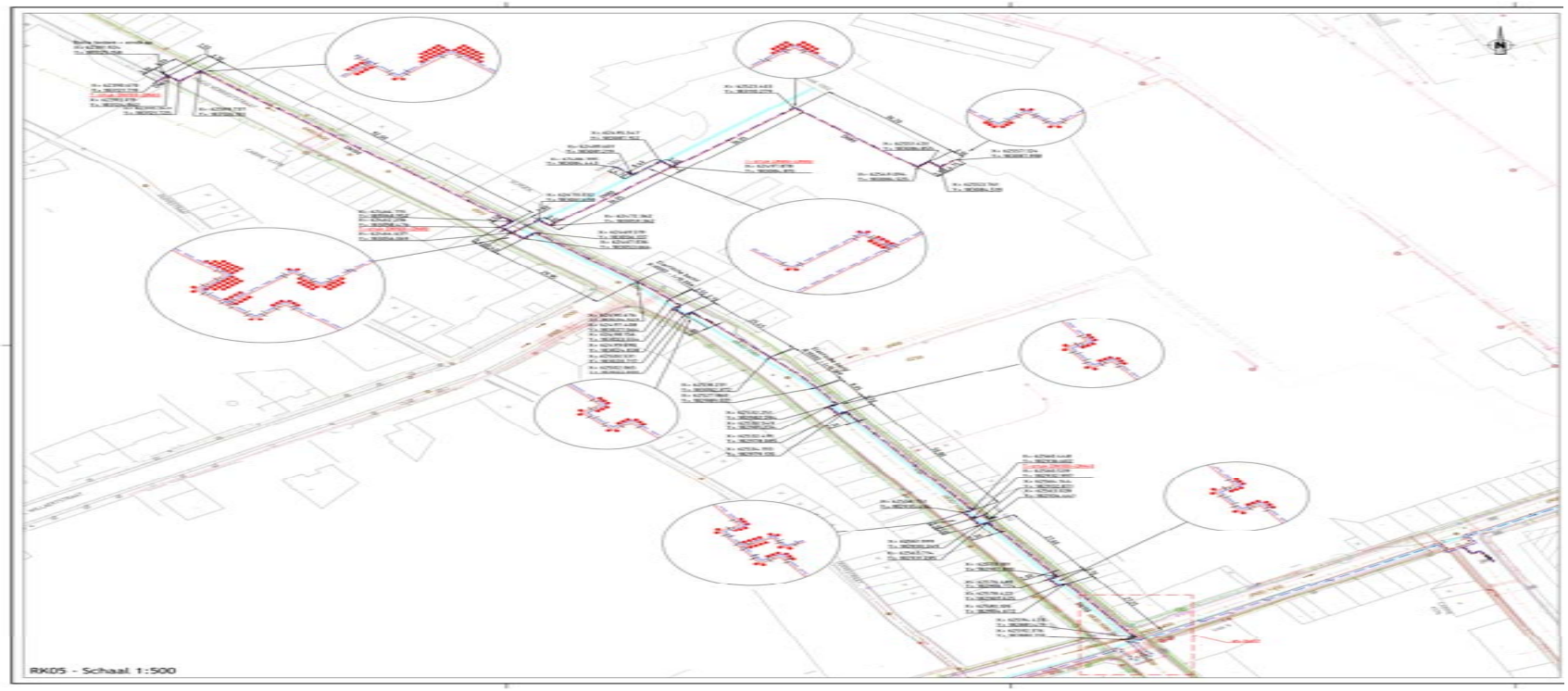
BENEFITS IN DESIGN.

If you want all the benefits of using the EN 13941 for designing, you have to use all of the standards.

This means among others:

- Pipes, fittings and joints shall be according the EN standards
- Weldings shall be according EN 13941. high quality and strict demands for misalignments.
- If doing so, its possible to make projects in projectclass A+B mainly by using design-manuals from pipesupplyer = lowering the cost for designing.

EXAMPLE FROM BELGIUM - 2017



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EN 13941 IN THE FUTURE

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THANK YOU FOR

YOUR ATTENTION