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The Pipelines Safety Regulations - Applying a goal-setting regime

Alan Thayne
HM Principal Inspector of Health & Safety

United Kingdom Onshore Pipeline Operators Association

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Applying a goal-setting regime

- **Introduction**
  - The Pipelines Safety Regulations and guidance
  - standards, good practice and ALARP
  - pipeline safety – influences
  - applying goal-setting – examples
  - final remarks

The Pipelines Safety Regulations

- **The Pipelines Safety Regulations 1996 SI825 (PSR)**
  - PSR made under The Health & Safety at Work etc. Act 1974
  - replaced earlier, prescriptive legislation
  - focus on management of pipeline safety
    - to secure pipeline integrity
    - covers both onshore and offshore pipelines
    - goal-setting in nature
    - allow risk-based approaches which have to satisfy the principle of SFAIRP
  - overall aim is to ensure that pipelines are designed and constructed properly and operated safely

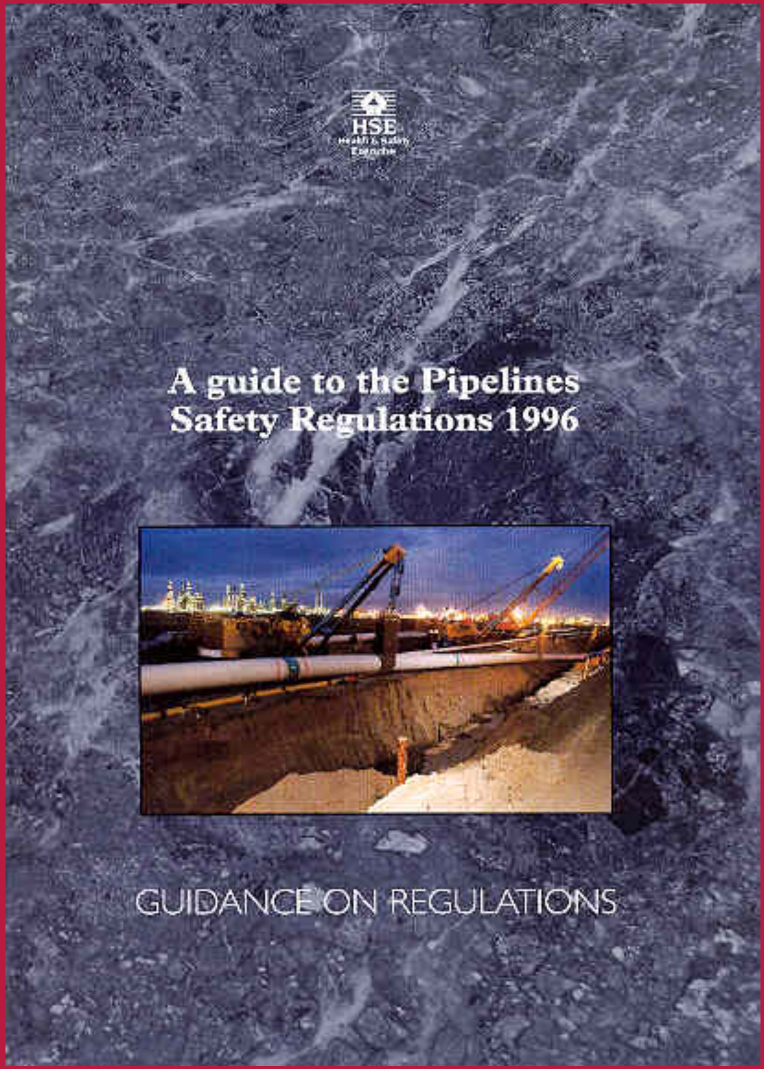
The Pipelines Safety Regulations

- **PSR covers:**
  - general requirements
    - design of the pipeline; safety systems; materials; operations; construction and installation; arrangements for incidents/ emergencies; examination and maintenance; damage & prevention; co-operation; decommissioning
  - Major Accident Hazard Pipelines
    - notifications to HSE prior to construction, use and certain modifications; Major Accident Prevention Document and emergency procedures.

PSR guidance

- **HSE has published guidance (and one ACoP) on complying with PSR which, while not law, give advice on measures available and what is good practice**
  - A guide to the Pipelines Safety Regulations 1996 (L82)
  - Further guidance on emergency plans for major accident hazard pipelines
  - A guide to regulation 13A of the Pipelines Safety Regulations 1996
  - Design, construction and installation of gas service pipes (ACoP L81)

The Pipelines Safety Regulations - Guidance (L82)



The Pipelines Safety Regulations – Further guidance on emergency plans

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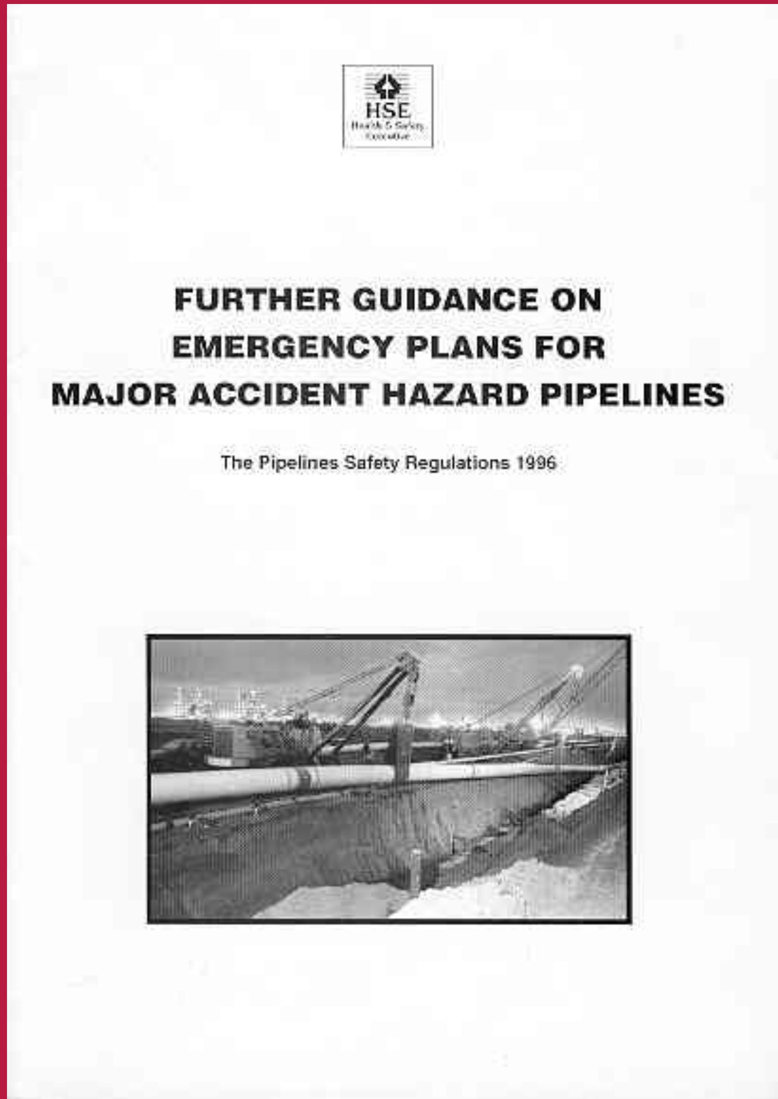
http://www.hse.gov.uk/pipelines/emergencyplanpipe.pdf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FURTHER GUIDANCE ON EMERGENCY PLANS FOR MAJOR ACCIDENT HAZARD PIPELINES

The Pipelines Safety Regulations 1996

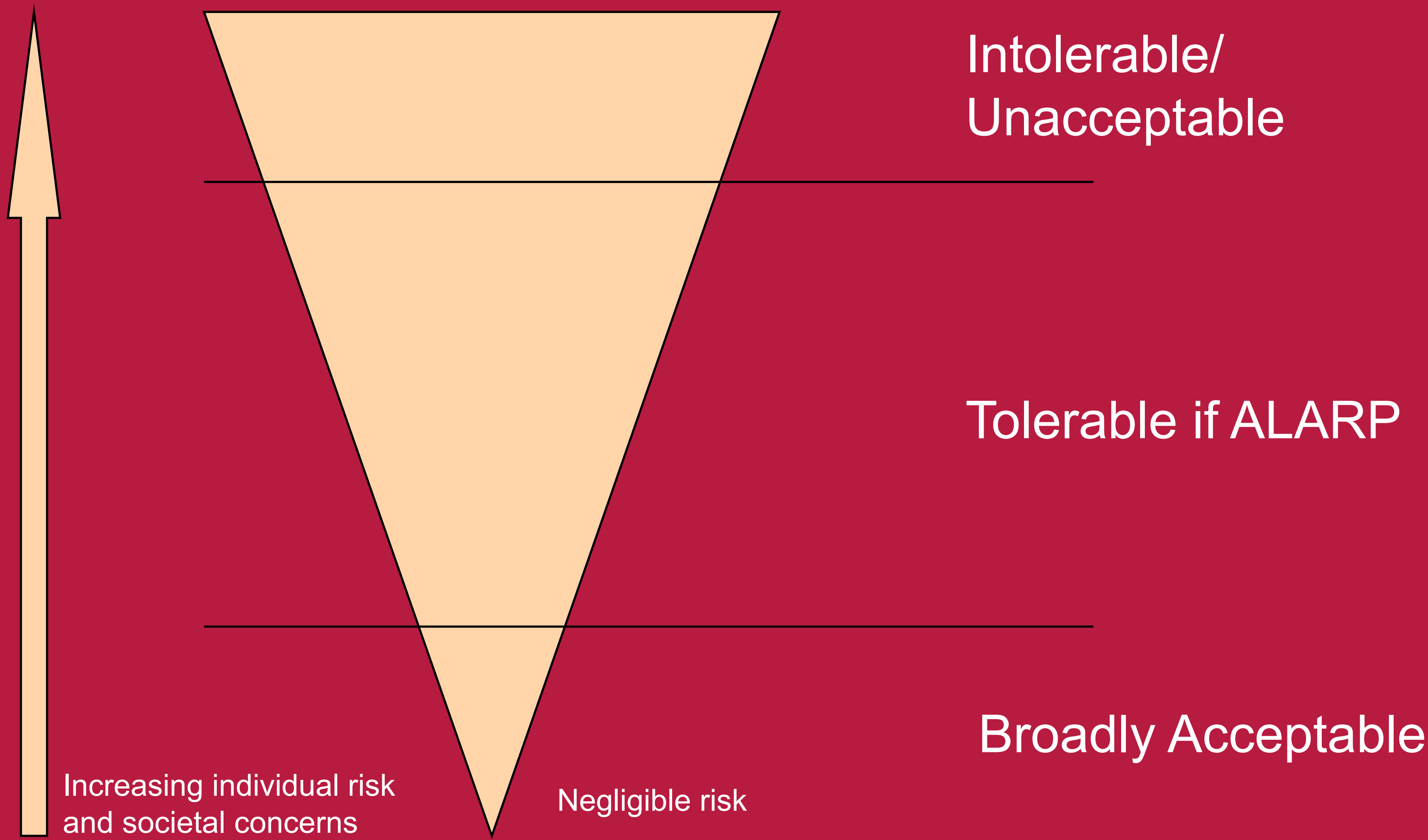
The Pipelines Safety Regulations

- **Absolute Duties - examples in General Duties:**
  - reg 8: materials – must be suitable
  - reg 10: work on a pipeline – must not affect its soundness and fitness for purpose
  - reg 11: operation of a pipeline – safe operating limits
  - reg 12: arrangements for incidents and emergencies
  - reg 13: maintenance – maintain in an efficient state, efficient working order and in good repair
  - reg 14: decommissioning – leave in safe condition

Good Practice – Standards/ Codes

- **BS EN 14161:2003** – Petroleum and natural gas industries – Pipeline transportation systems
- **BS EN 1594:2000** – Gas supply systems – Pipelines for maximum operating pressure over 16 bar – Functional requirements
- **BS PD 8010-1:2004** - Code of practice for pipelines – Part 1: Steel pipelines on land
- **IGE/TD/1 Edition 4:2001** – Steel Pipelines for High Pressure Gas Transmission

Criteria for the tolerability of risk



Pressures on pipeline safety

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- **Pipeline environment – not static**
  - mature and ageing infrastructure – reaching/ passed design life
  - extending operating parameters for existing infrastructure, eg gas transmission uprating, interconnector uprating
  - "new" categories of fluid, eg CO_2
  - working beyond accepted or established good practice
  - new or less experienced operators and/ or pipelines not their core business
  - loss of expertise and corporate knowledge/ memory/ lessons from the past
  - new approaches to pipeline integrity management
  - research – may be less supported/ co-ordinated
  - changes in oil and gas prices – effects on integrity

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Applying goal-setting

Examples of application

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- **Goal setting regime – coping with new developments and problems**
  - uprating of part of the gas transmission network
  - uprating an international interconnector
  - offshore installation risers – concerns over integrity
  - one pipeline – two pressures
  - pipeline integrity – a new approach to maintenance
  - block valve spacing
  - CO_2 pipelines

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Uprating a Gas Transmission Network

Pipeline uprating project

- **Approach**
  - onus on the operator to make the case – to justify and to demonstrate continued pipeline integrity
  - a need to develop and agree the form of the case, including:
    - the specific part of the pipeline system to be uprated (identify particular pipelines, AGIs, compressor stations, block valves, etc.)
    - identify new risks and balance increased risks during and after pressure raising
    - maintain pipeline system integrity
    - develop new operating and maintenance regimes
    - land use planning implications
    - independent audit of key areas of methodology, eg operator's limit state principles

Pipeline uprating project

- **Data gathering, inspection and surveillance**
  – basis of original design
  – material properties search and calibration against known samples
  – fabrication/ construction records/ concessions
  – inspection/ surveillance records
  – incident data
  – operational/ fatigue/ CP history
  – modification/ repair history
  – data remediation/ uncertainty analysis/ default values
  – QA/QC records/ document control (of the process)
  – survey route for infrastructure infringements

Pipeline uprating project

- **Technical assessment**
  - identify all credible failure modes
  - assess the failure probability following uprating and demonstrate any increase is acceptable
  - carry out structural reliability analysis knowing mechanical properties, geometry, loads and residual strength
  - assess susceptibility to SCC
  - consider affects of ground movement and other causes of axial loading
  - assess fatigue life of pipe and fittings

Pipeline uprating project

- **Revalidation of pipeline**
  - most National Transmission System pipelines were originally high level strength tested to ensure freedom from defects – eg at 105% SMYS for 24 hours
  - decision needed on hydrostatic testing (to retain test/ operating pressure ratio) versus OLI and FFP assessment to quantify significance of defects, etc.
  - OLI carried out before uprating to minimise risks of third party damage and other defects going unnoticed

Pipeline uprating project

- **Modifications to the pipeline system (inc. upgrading)**
  - take full account of AGIs, block valve sites, compressor stations, etc. – assess to IGE/TD/12 and upgrade/ uprate in accordance with IGE/TD/13
  - AGIs/ BVs designed to ASA Class 600 but still need to assess plant and equipment such as pig traps, filters, WBHs, metering, valve actuators, etc.
  - major upgrades required at compressor stations
  - special consideration needs to be given to pipeline upgrading at crossings, close to vulnerable or large populations, at infringements, etc.

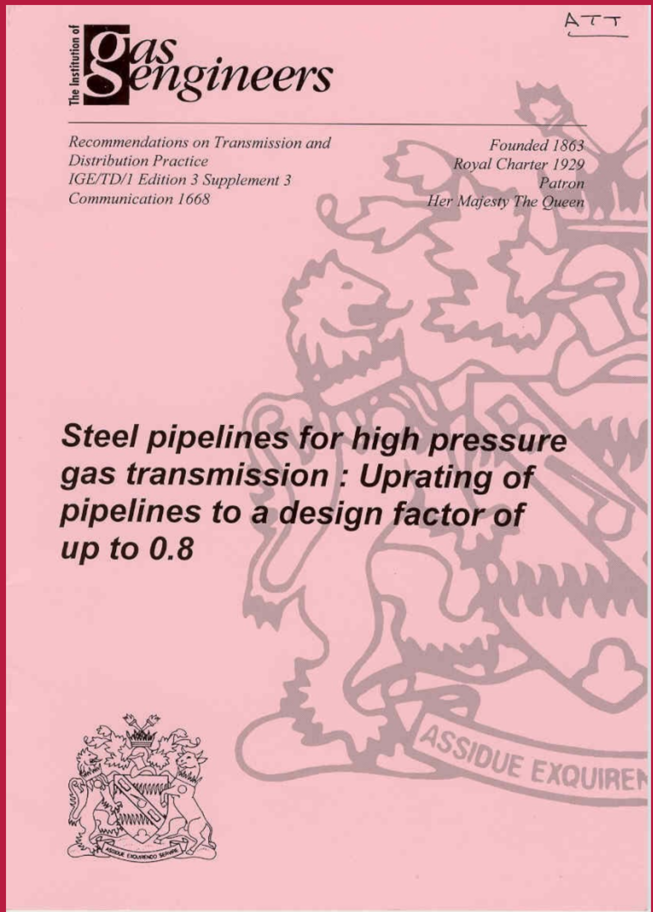
Pipeline uprating project

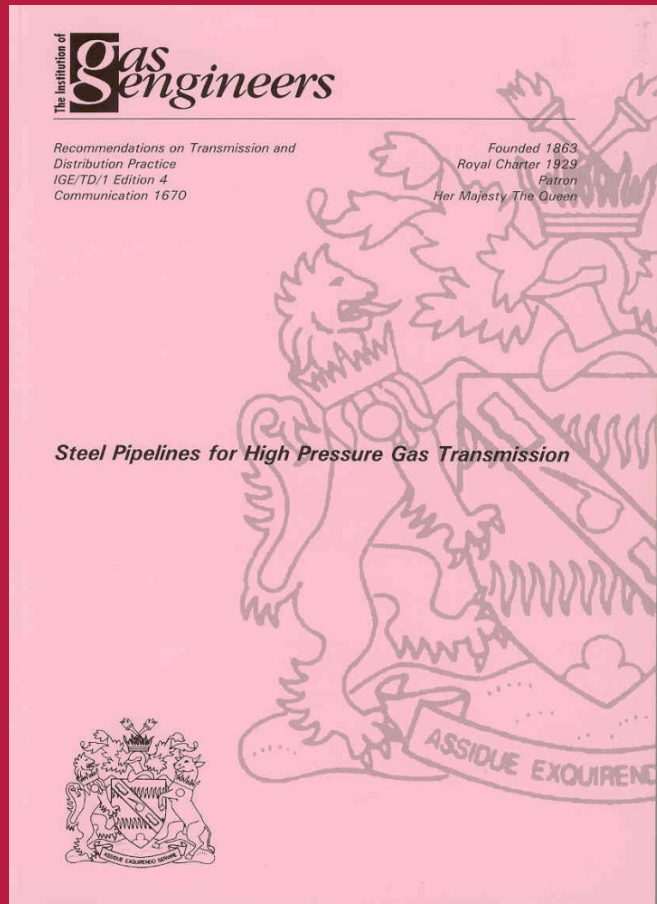
- **Pressure raising and subsequent operations**
  - formal review and acceptance of all previous work before uprating can proceed
  - develop procedures for uprating
  - carry out leakage surveys after uprating
  - improve pipeline location markers to help minimise third party damage
  - revise and enhance inspection, surveillance and maintenance schedules to reflect elevated risk

Pipeline uprating project

- **HSE's involvement**
  - team formed of pipeline inspectors and risk assessors to consider proposals
  - comparisons made with other pipeline codes
  - frequent contact/ meetings with operator
  - input from HSE's own laboratories on materials – eg fracture propagation and SSC
  - required independent reviews and audits on behalf of operator and for HSE
  - considered future land use planning implications
  - accepted overall project in principle only – still assess individual uprating proposals
  - needed high level (HSE Board) "acceptance"
  - developed guidelines for inspectors
  - promoted update of codes and actively involved in development of IGE Recommendations
  - inspection

Institution of Gas Engineers Recommendations for Transmission and Distribution Practice





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Uprating an International Interconnector

Uprating an international interconnector

- **Background**
  - part of a multi-stage programme to meet need to significantly increase capacity
  - predominantly an offshore pipeline but with onshore sections
  - pipeline crosses international boundary – regulatory/ authorities issues

Uprating an international interconnector

- **Approach**
  - regulations/ codes
    - national regulatory requirements, principles of IGE/TD/1 Ed 4 applied for uprating, review of standards used
  - integrity assessment
    - original design basis; hydrostatic test history; acceptability of fittings, linepipe and equipment at higher pressure; fatigue; etc.
  - condition assessment
    - operating history; modifications; repairs; inspections; corrosion survey
  - risk assessment
    - revised assessments of individual and societal risks on land section
  - hardware requirements
    - instrumentation and control; hazardous areas; functionality of valves and actuators; civils and structures; additional over-pressure protection (HIPPS); etc.
  - uprating procedure

Uprating an international interconnector

- **Issues**
  - uprating pushes design factor above established limits – of more concern for land section
  - effect on existing terminal plant, over-pressure protection
  - a mix of pipeline codes
  - non-standard method of calculating hoop stress
  - most of the pipeline hydrostatically pressure tested to higher pressure already
  - good records have been a great help

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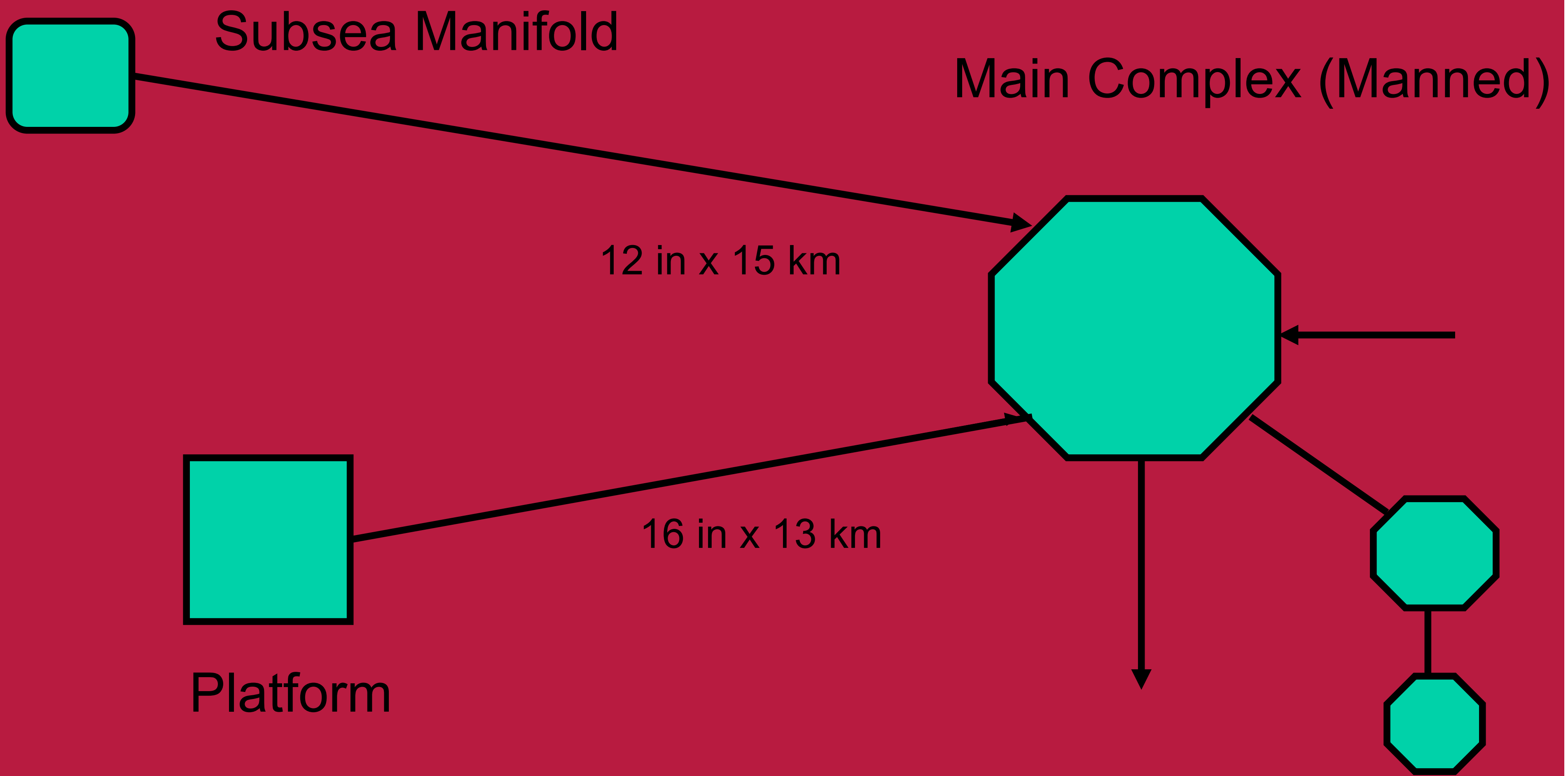
The Weakest Link?

The Weakest Link?



The Weakest Link?

- Features:
  - design pressure (16in and 12in) – 97 barg
  - WHSIP:
    - platform = 280 barg
    - subsea manifold = 250 barg
  - Hoop stress at 280 barg for 16in riser = 428 MPa
  - Hoop stress at 250 barg for 12in riser = 323 MPa
  - SMYS = 448 MPa (both risers)
  - UTS = 530 MPa (both risers)

The Weakest Link?

HSE

- Codes
  - BS 8010 Part 3 section 4.2.1.2 - “ In selecting the internal design pressure, consideration should be given to the maximum steady shut in pressure and also the well kill pressure where pipelines are connected to wells. During the design process the target MAOP will generally be identical to the internal design pressure and protection systems should be considered to ensure the transient pressures do not exceed 110% of the MAOP.”
  - API RP 14C – for pipelines with input source pressure greater than MAOP API RP 14C recommends shutdown of pumps/comps’/SDV and a PSV on the input source. For connection to wells two SDVs in lieu of PSV may be used but with independent pressure sensors, relays, etc.

    Consideration may be give to a PSV as well as two SDVs.

The Weakest Link?

HSE

- Background:
  - pre-installed risers were not designed for any particular project and were they suitable for proposed duty? Could the operator justify their use?
  - risers were “weakest link” in pipeline system – did this matter?
  - was the pipeline system designed to code? (eg BS 8010 Part 3)?
  - were the risks to the risers/installation ALARP – could more be done?
  - was the use of engineering critical assessment to determine fitness-for-purpose acceptable to HSE?

The Weakest Link?

- 12 inch pipeline from subsea manifold
  - integrity assessment - riser unlikely to fail under maximum WHSIP
  - wider risk picture:
    - riser 105 metres from TR
    - required multiple failure of subsea wellhead/ HIPPS systems
    - time taken for pressure to reach WHSIP ~ 12 hours
    - well pressure dropping to riser test pressure (160 barg) after six months operation

The Weakest Link?

- 16 inch pipeline from platform – riser integrity
  - operator provided a demonstration of integrity based on combination of theoretical assessment, inspection and tests
  - engineering assessment of riser pipe, welds, flanges and other joints
  - problem of low fracture toughness identified in riser circumferential welds – high risk of weld failure at WHSIP at temperatures of 4 deg C or less
  - inspection of riser found wall thickness at design minimum but no allowance for corrosion

The Weakest Link?

- 16 inch pipeline from platform – riser integrity (cont'):
  - welding of test pieces to simulate production welds created own uncertainties
  - reluctance to carry out pressure test at 280 barg or 90% SMYS – only tested riser to 160 barg – fears of introducing weaknesses – this was major problem in the assessment of their case

The Weakest Link?

- Assessment conclusions for riser integrity:
  - riser weakest link in pipeline system
  - overall conclusion by operator was that riser should take WHSIP with worst case assumptions
  - interim Verification Statement – agreed in principle with approach taken by operator
  - actual yield stress margin over SMYS ~10-12% - but may not cover uncertainties
  - riser pipe design factor ~ 0.88
  - riser bends design factor ~ 0.85

The Weakest Link?

- Assessment conclusions for riser integrity (cont'):
  - flanges, bolts, sealing rings all capable of taking WHSIP
  - remaining concerns over fracture toughness of welds
  - corrosion management – tackled by HSE inspection
  - overall conclusion by HSE – "…riser may be capable of withstanding WHSIP – but, it may not – it is too close to call. There remains a great deal of uncertainty which may never be removed entirely…if the required demonstration cannot be made (and it may be impossible to do so) then the operation of the riser has to be considered in a wider context"

The Weakest Link?

HSE

- New risers – options hierarchy:
  - eliminate hazard
  - promote designs that are inherently safe – eg cope with WHSIP for pipelines connected to subsea wells or NUIs
  - adopt a no-burst approach with secondary protection
  - "passive" protection systems plus manual intervention – but may not be considered acceptable
  - "active" protection systems only not considered acceptable
- Note: API 14C requires two diverse methods (passive and active)
- Note: inventory may determine approach

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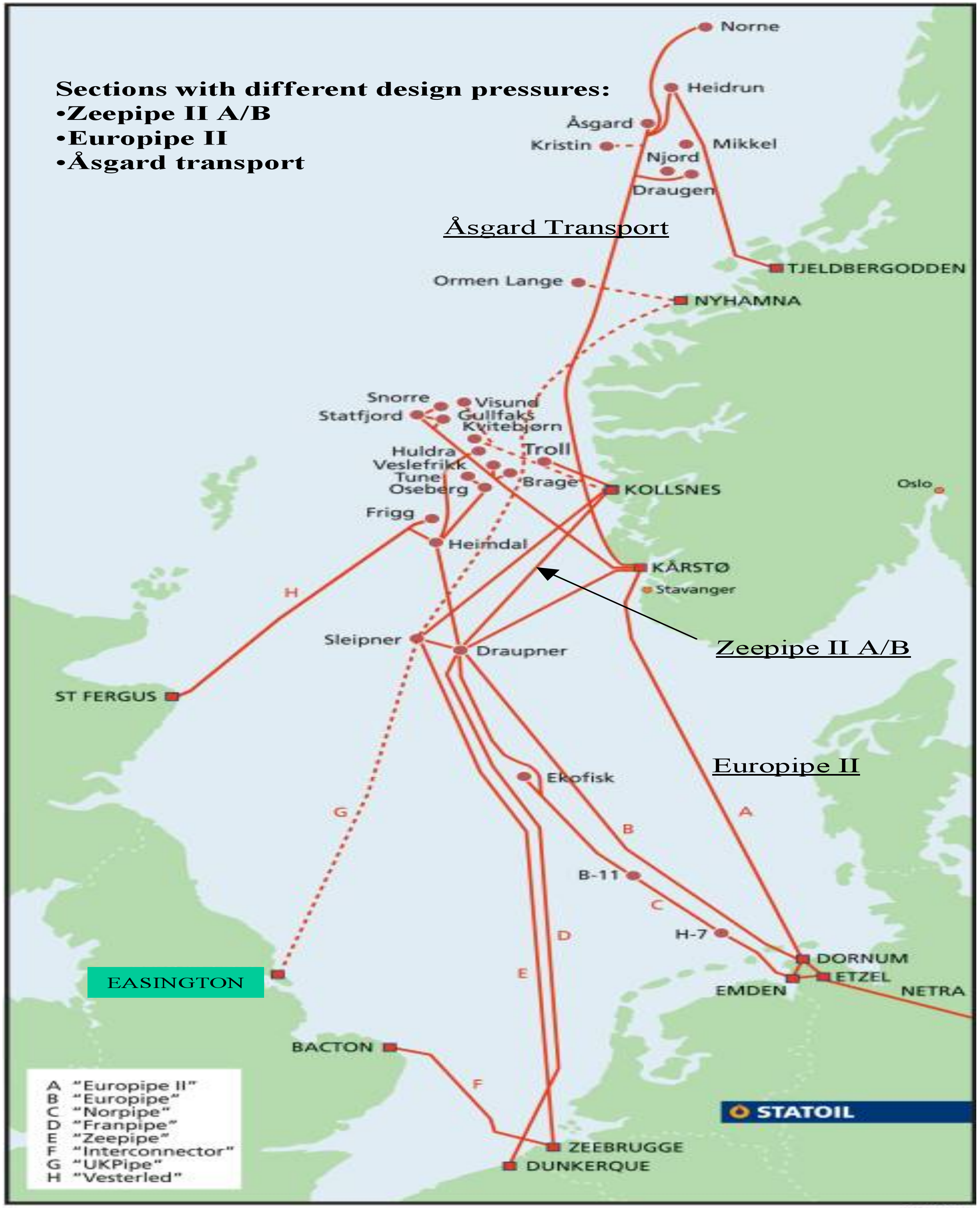
One Pipeline – Two Pressures

Sections with different design pressures:

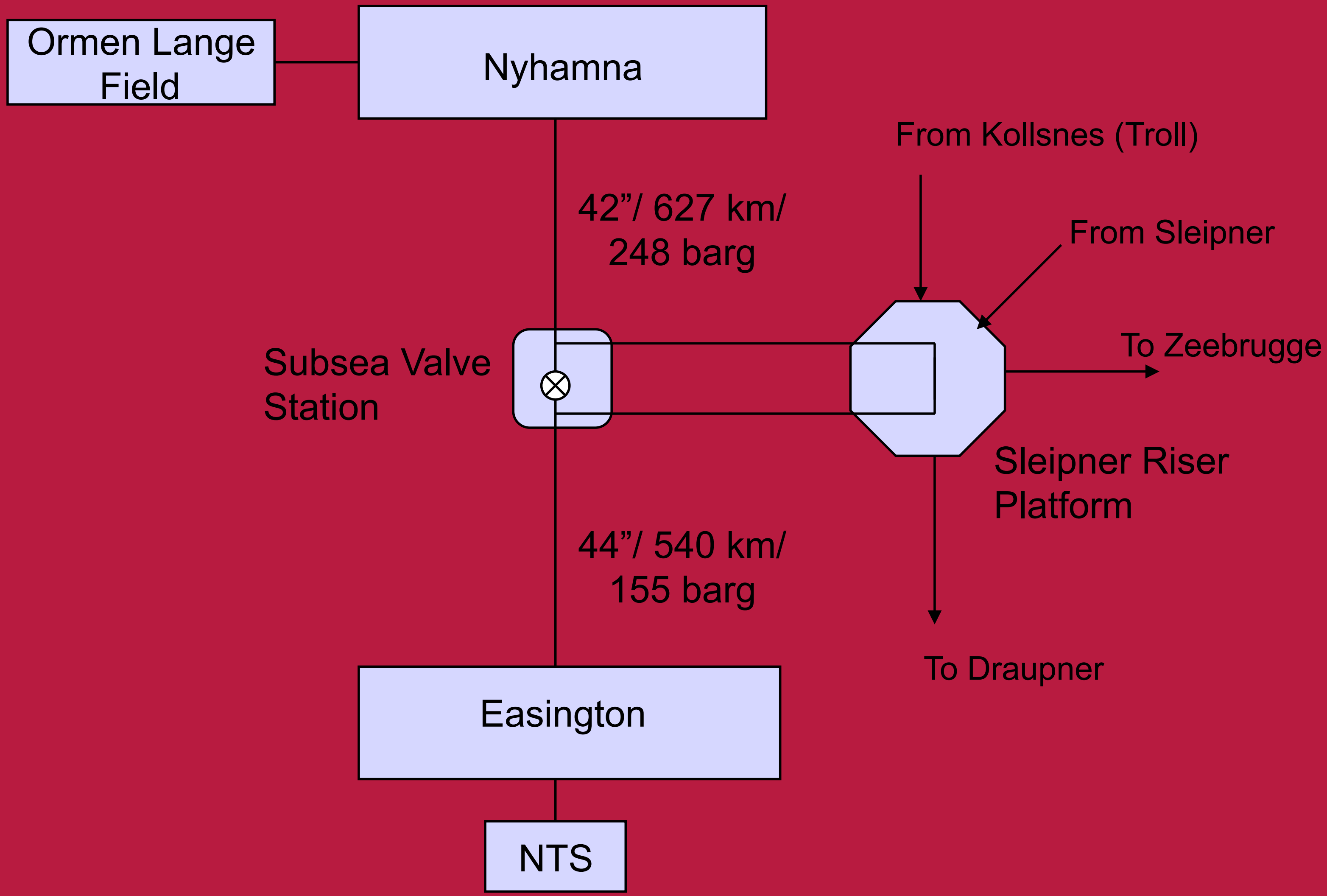
- **Zeepipe II A/B**
- **Europipe II**
- **Åsgard transport**



Ormen Lange Transport – main features

Feature	Nyhamna - Sleipner	Sleipner - Easington
Diameter	42 inch (30 inch riser at Sleipner)	44 inch (30 inch riser at Sleipner)
Length	627 km	540 km
Design Pressure/ MOP	250.0 barg/ 248.0 barg	156.8 barg/ 155.0 barg

Ormen Lange Transport - system



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Direct Assessment of Pipeline Integrity

Pipeline integrity assessment

HSE

- Direct Assessment
  - "a structured process that defines locations where a pipeline is examined to provide assessment of pipeline integrity"
  - still fairly new (?)
  - NACE RP 0502 approach involves pre-assessment; indirect inspection; direct examination and post-assessment
  - similar approach applied successfully for pipeline where all of the pipeline could not be OLI'd
  - proposals for Direct Assessment of 138 km offshore pipeline, but more needed for proper demonstration of integrity

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Block Valve Spacing

Block valve spacing

HSE

- An unexpected result:
  - IGE/TD/1 Ed 2:1984 & BS 8010 Pt 2.8:1992 - used traditionally accepted view of 10 miles/ 16 km between block valves
  - IGE/TD/1 Ed 3:1993, BS EN 1594:2000, BS EN 14161:2003 & BS PD 8010: 2004 – not prescriptive - allowed optimisation provided certain factors taken into account
  - Pipeline Research Council International, Inc. produced a report "Valve Spacing Basis for Gas Transmission Pipelines" in Jan 2000 which provided a basis for determining valve spacing
  - justification for new spacing applied to various gas transmission pipelines – eg 48 inch Bacton to Kings Lynn, 48 inch Milford Haven to Tirley, etc.

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High Pressure CO_2 in Pipelines

High pressure CO_2 in pipelines – a new hazard?

- **CO_2 - a potential new major hazard?**
  - limited experience in handling large scale CO_2 flows
  - harmful health effects as a result of exposure
  - little data on dynamics of CO_2 releases
  - toxic contamination
  - grit blast effect
  - cooling effects
  - detection and emergency response

High pressure CO_2 in pipelines – case for safety

- **Operator to demonstrate safe operation of complete pipeline system through:**
  - pipeline fitness for purpose studies
    - review original design & design life
    - impact of CO_2
    - engineering analysis of the pipeline in new mode
    - describe and analyse current condition
  - pipeline risk assessments
    - identify and assess CO_2 risk scenarios
    - based on release modelling with input from testing
    - QRA based approach
    - quantify impact on local population

High pressure CO_2 in pipelines – case for safety

- **Issues**
  - – adequate fitness for purpose demonstration for an existing pipeline in CO_2 service?
  - – suitable pipeline codes?
  - – materials, fracture toughness and running ductile fractures
  - – integrity of non-metallic materials (eg seals)
  - – leak detection
  - – integrity management strategy
  - – experimental testing and release modelling

Final remarks

- **Goal-setting:**
  - needs a robust regulatory regime and good guidance
  - may require active participation of the regulatory authority
  - has to be based on recognised and accepted standards
  - requires competent “players”
  - allows well engineered and managed alternatives
  - promotes new technology and methods
  - not necessarily the easiest option – challenging
  - is there too much emphasis on risk and not enough on consequences?