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Experience with the Pressure Uprating of Gas Transmission Pipelines in the UK

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PHMSA Public Meeting: 'Natural Gas Pipeline Maximum Allowable Operating Pressure for Class Location', Washington. March 21st 2006.

UK Gas Transmission Uprating

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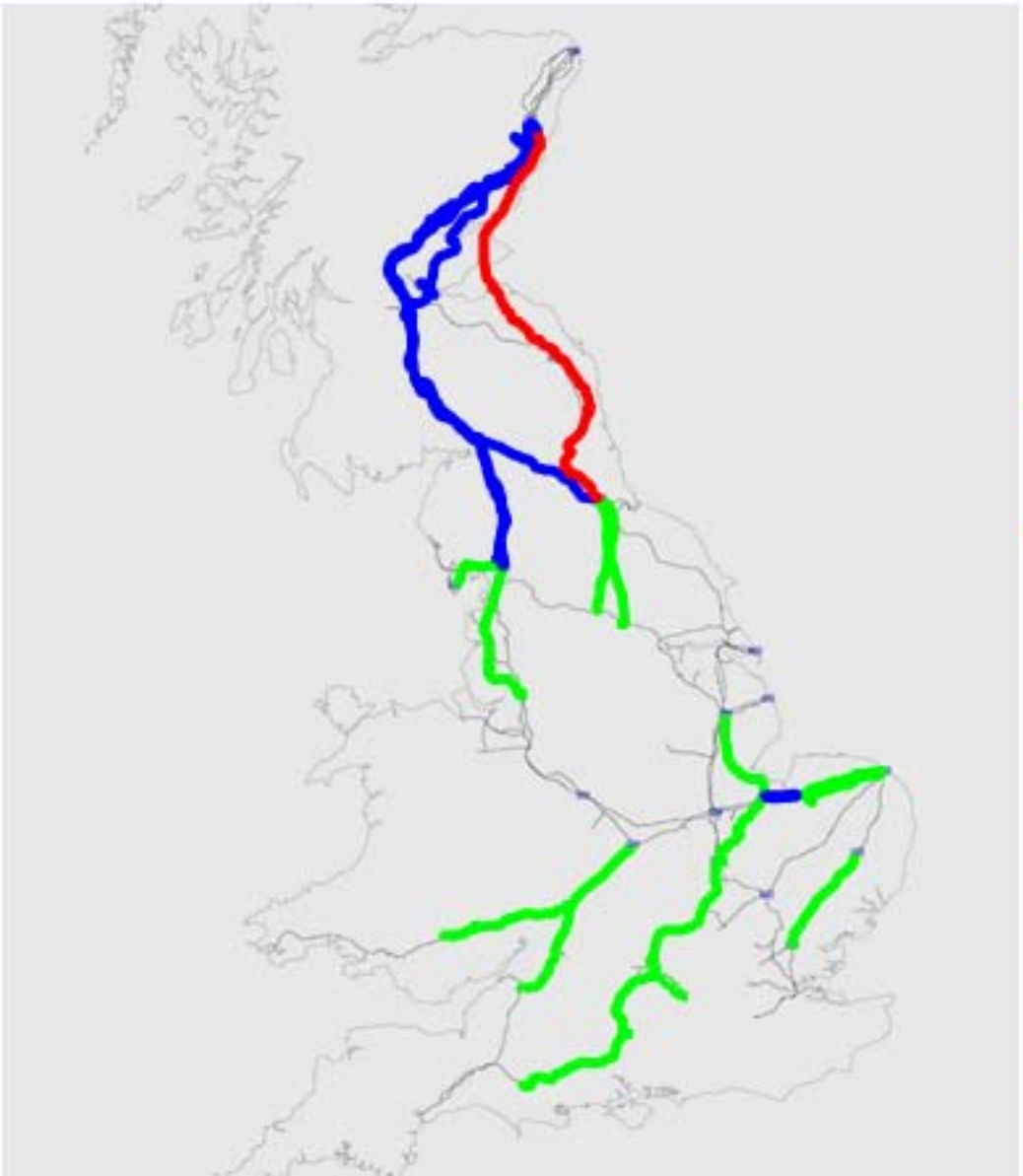

1233 psig

1218 psig

1088 psig

No failures in uprated pipelines

GENERAL

In the last 10 years, around 30% of the 3,800 mile bulk transportation system has been uprated to a maximum of 80% SMYS, saving an estimated $800M while enabling the Northern pipeline system to transport an additional 12% of the total UK gas demand.

Scale: top to bottom = 600 miles

Initial Pipeline Uprating in UK

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- UK gas industry required to provide 'efficient' gas transportation
- Pipeline uprating efficient method to increase capacity
- Detailed technical evaluation prior to uprate:
  - Operational record review
  - Comprehensive survey of infrastructure
  - Design code compliance checks
  - In-line inspection to determine corrosion condition
  - Modification and/or repair, as necessary
- 1984 - first uprating to 1088 psig
- 1989 - 500 miles uprated to 1088 psig

BULLET 1
From 1949, the gas industry has operated under UK legislation known as the ‘Gas Act’. A requirement within this Act has been for the industry to provide an **efficient** means of transporting gas.

BULLET 2
During the late 1970s it was concluded that the maximum operating pressure (MOP) could be increased from generally 1015 psig to 1088 psig without exceeding the design factor limit of 0.72 . Also, because minimal physical modification would be required it was recognised that such pressure uprates could be achieved at minimal cost and would be an efficient means of increasing capacity of the UK system.

BULLET 3
It was decided that such pressure uprates should be carried out pipeline-by-pipeline, as and when the gas supply situation demanded, and that detailed technical evaluation would be required for each case.
The technical considerations were those already identified in the relevant pipeline operating code and the evaluations involved:

- A detailed check of design code requirements for the pipelines for operation at the uprated pressure
- A comprehensive survey of the pipeline route to identify any infrastructure infringements by the pipeline at the uprated pressure. Infringements might be of either the population density limit or the building proximity distance limit (equivalent to a set back distance)
- Detailed inspection of the pipeline
- Assessment of any features identified
- Review of operational records to confirm fitness-for-purpose for operation at the uprated pressure

BULLETS 4+5
The first pressure uprate on UK pipelines was commissioned in 1984 then several more followed until by 1989 some 500 miles (800km) (15%) of the UK system was operating at 1088 psig (75bar).

UK Regulatory Environment

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- 1949-1995
  - Gas industry was self-regulating
- 1996
  - Structural change to industry
  - Independent regulation
- Safety regulations are 'goal-setting'
  - Define WHAT is to be achieved, not HOW
- Pipeline operators must satisfy safety regulator
- Risk levels must conform to ALARP principle
  - 'As low as reasonably practicable'
- Established codes are ALARP

BULLET 1
Effectively, until 1989 the UK gas industry was British Gas who supplied the majority of gas through their own pipeline system and was largely self-regulating.

BULLET 2
Subsequent change to industry structure required safety aspects of gas transportation to be independently regulated by the UK safety regulator and in 1996 pipelines safety regulations were published. The regulations identify the responsibilities of both the pipeline operators and the safety authority.

BULLET 3
An important feature is that they are ‘goal-setting’ i.e. they do not instruct operators how to maintain safety but identify the results required. However, the overall objective is to maintain or improve safety levels and pipeline operators are required to demonstrate that their systems are safe.

BULLET 4
The regulations plus official published guidance mean that pipeline operators must ensure that the safety implications of any uprate are fully considered. Also, pipeline operators must document the results of the safety evaluations for audit. The safety regulator has powers to ‘object’ to the proposed uprate and to prevent it from proceeding.

BULLETS 5+6
A further consideration is overall UK health and safety legislation that requires risk to be reduced to levels ‘as low as reasonably practicable’ (ALARP). Established codes are considered ALARP. Otherwise, demonstration of ALARP can require consideration of the cost, time and physical difficulty of implementing measures to reduce risk.

Uprating Out-of-Code

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- Need to increase pipeline capacity
  - Both uprating and new-build
- Uprate pressure 1233 psig
  - Design factor 0.78
  - Code limit 0.72
  - Out of code
- Safety regulations and guidance
  - Integrity and risk evaluation
- Feasibility of Fitness-for-Purpose required

BULLET 1
By 1996 the operator of the UK system had determined a requirement to substantially increase transmission pipeline capacity from gas fields in the North to markets in the South. The required increase in capacity could be achieved through a combination of new-build and up-rating of existing pipelines.

BULLET 2
The uprated pressure required was 1233 psig. This would result in a design factor of 0.78 on the existing 36in pipelines and would exceed the operating code limit of 0.72.

BULLET 3
Under general UK health and safety regulations, proper operation of industrial assets in accordance with established codes is considered generally 'safe' and any resulting risks 'ALARP'. However, the pipelines safety regulations are explicitly 'goal-setting', meaning that operators of pipelines are not restricted to prescriptive design codes and instead can base their design and operation on 'fitness-for-purpose' provided this addresses all integrity and risk implications.

BULLET 4
A feasibility study was conducted to determine whether the pipelines would remain safe following the proposed increase of design factor. This involved a detailed safety evaluation comprising comprehensive integrity assessment and risk analysis. Also, close liaison was initiated and maintained with the safety regulator to enable any concerns they might express to be addressed at the earliest opportunity.

Feasibility Conclusions

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- 0.72 limit
  - No structural significance
- Failure probability at 1233 psig
  - Acceptably low
- Risks to population at 1233 psig
  - As low as reasonably practicable (ALARP)
- Risk of SCC
  - Negligible
- Safe operation at 1233 psig
  - Feasible
- Detailed safety evaluation for each pipeline
  - Required

The overall conclusions arising from the feasibility study were:

BULLET 1
The 0.72 design factor limit had no structural significance

BULLET 2
Failure probability of the pipelines while operating at 1233psig would remain acceptably low

BULLET 3
Risks to the population surrounding the pipelines would be ‘as low as reasonably practicable’

BULLET 4
There was negligible risk of SCC

BULLETS 5+6
It was likely that the pipelines could be safely operated at 1233 psig, subject to detailed safety evaluation of each individual pipeline

Liaison with Safety Regulator

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- Matters of Principle agreed
  - Data assessment
  - Integrity assessment
  - Risk assessment
  - Safety justification
  - Liaison with safety regulator
- Inspection & maintenance strategy reviewed
  - Existing
    - Consistent with USA for >0.80
  - Additional I&M considered
    - Particular I&M activities
    - Benefits quantified
    - Applied in accord with ALARP principle

GENERAL

The safety regulator paid close attention to the results that arose from the feasibility study. Initially they were sceptical of operation outside the design code, but after further consideration they accepted that the proposed approach was acceptable. Having accepted the overall concept of up-rating, they still separately considered each proposed up-rating in detail. They requested from the project team a number of items to assist their considerations during the project team's execution of the detailed safety evaluations. In particular:

BULLET 1

'Matters of Principle' were developed to clearly define and proceduralise the safety evaluation process. These covered:

- Data assessment
- Integrity assessment
- Risk assessment
- Safety justification
- Liaison with safety regulator

BULLET 2

The inspection and maintenance strategy for the uprated pipelines was reviewed then benefits of particular additional I&M requirements were identified. For each affected pipeline, the benefits of additional requirements were to be evaluated in accordance with the ALARP principle.

Methodology

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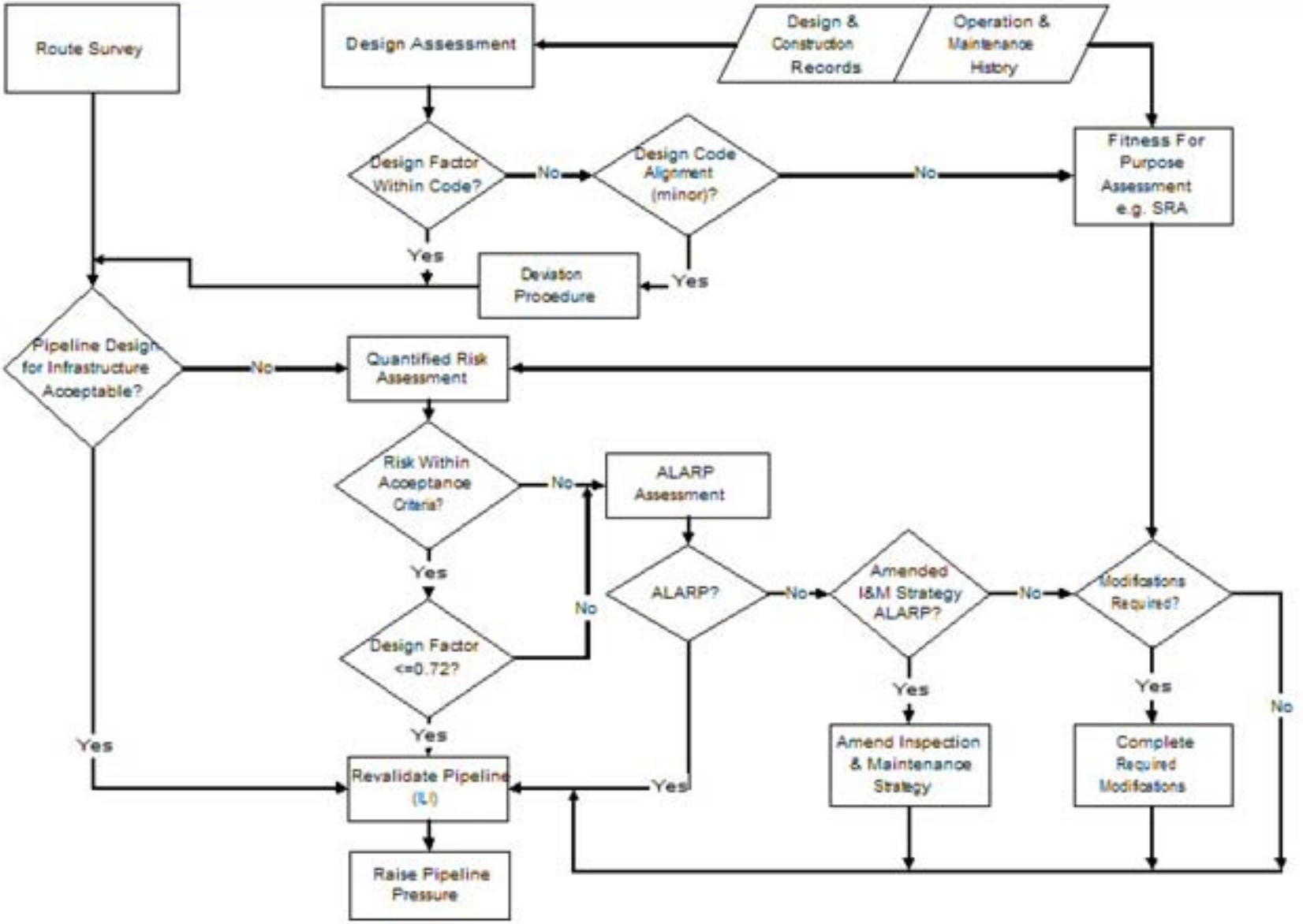

Methodology requires:

Data integration - design, construction & operation data
Check of compliance with design code
Fitness-for-purpose of integrity non-compliance
Quantified Risk Assessment of infrastructure non-compliance
Consider ALARP
In-line inspect for corrosion
Modify and repair as necessary
Raise pressure

Pipeline Code Revision

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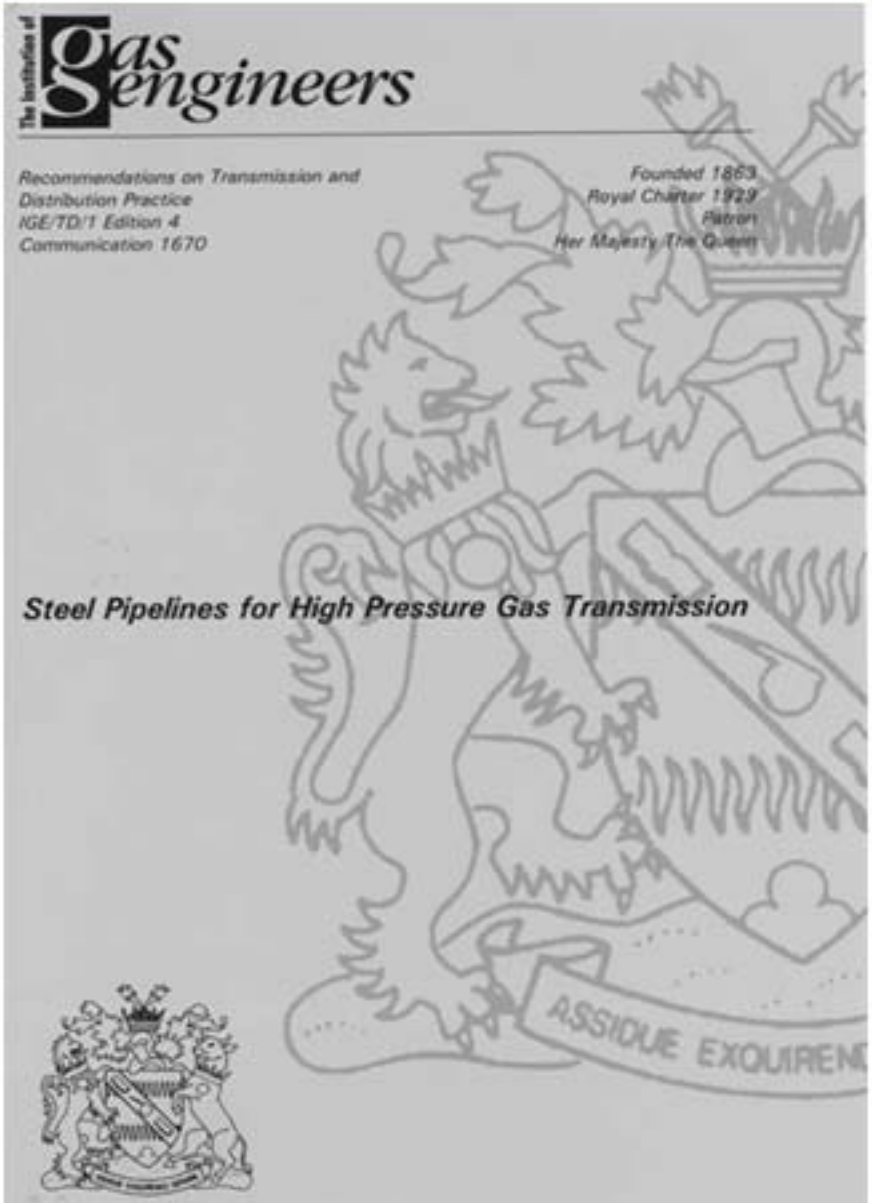

- IGE/TD/1
  - Technical work submitted
  - Considered by professional body
  - New upper limit of 0.80 accepted
  - Code revised to include new uprating recommendations
  - Edition 4 published 2001

The technical work to justify up-rating of pipelines to design factors >0.72 was submitted to IGE, the UK professional body responsible for the relevant code.

IGE decided that 0.80 was an appropriate maximum for consistency with other standards e.g. ASME B31.8.

The pipeline code was amended and was re-published during 2001

Now covers all the issues first raised during the 1233psig uprating project.

Advantica Safety Evaluation

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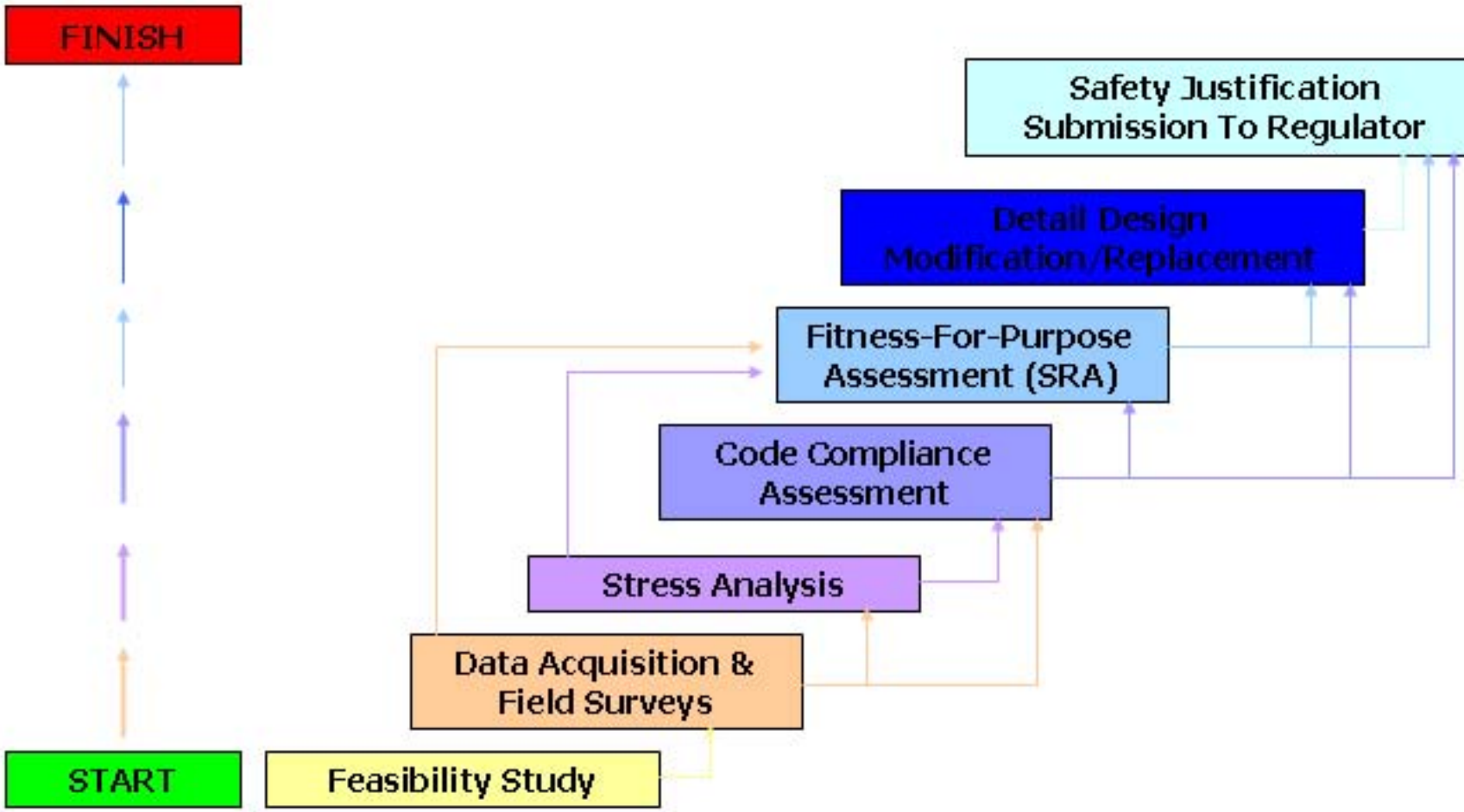

The procedure for preparation of uprating safety justifications for submission to the UK safety regulator have evolved.

CURRENT PROCEDURE USED BY ADVANTICA

Safety Evaluation Report Structure

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Generally, for pipeline upratings there are seven documents produced by Advantica. These cover:

1. Data for conceptual design studies
2. Pipeline CODE COMPLIANCE
3. Pipeline FITNESS-FOR-PURPOSE
4. Above Ground Facility CODE COMPLIANCE
5. Above Ground Facility FITNESS-FOR-PURPOSE
6. Modifications required
7. Safety Case

Recent Advantica Contribution

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- Principal contractor for first uprating to 0.80
  - Full engineering control
  - 233 miles of 42 in.
  - Pressure 1218 psig
  - Commenced 2002
  - Completed 2004
- Other safety justifications
  - 71 miles of 36 in
  - Pressure 1233 psig
  - Completed 2005

BULLET 1
One recent project was for the uprate of a 42in. pipeline to a design factor of 0.80, the first time the new maximum design factor had been used in the UK. That contract was awarded to Advantica and the pipeline pressure was successfully raised during 2003.

Implementation Issues & Solutions

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Issue	Year	Tactical Solution	Strategic Solution
Large no. of above ground facility re-hydrotests identified, required shutdowns operationally very difficult	1	Most difficult shutdowns re-scheduled for Years 2, 3 & 4. Easier Year 1 hydrotests carried out	Feasibility of inspection & analysis alternative to re-hydrotest investigated
	2	Year 2 hydrotests scheduled for late in season. Results from alternative inspection & analysis methodologies accepted and all Years 2,3&4 hydrotests then cancelled.	Interim methodology demonstrated Year 2 hydrotests not required.
	3		Final methodology demonstrated Years 3&4 hydrotests not required.
	4		

Technical work was done by Advantica in close association with operator's Project Team.

Tactical solution was to schedule the re-hydrotesting as late as possible in the programme. Intent was to do the testing if the alternative inspection & analysis did not give a satisfactory solution.

Implementation Issues & Solutions

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- ILI feature required repair before uprating to full pressure
- Operator withdrew permission to repair. Uprating still required to meet seasonal demand
- Negotiation: concludes that lower pressure feasible to meet demand
- Feature acceptable without repair at intermediate pressure interim uprating carried
- Epoxy shell repair finally complete following summer
- Pipeline uprated to full pressure

Implementation Issues & Solutions

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- Following modification & repair, pressure raised to new MAOP
- Pipeline operator does not control gas supplies
- Shortfall in anticipated supply at scheduled time of pressure raising means new MAOP may not be reached by online compression
- For parallel pipelines, sequential isolations scheduled then pressure raised with mobile recompression units

UK Uprating Complete (1)

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1233 psig

1218 psig

1088 psig

GENERAL

In the last 10 years, around 30% of the 3,800 mile bulk transportation system has been uprated to a maximum of 80% SMYS, saving an estimated $800M while enabling the Northern pipeline system to transport an additional 12% of the total UK gas demand.

This map also shows earlier upratings

UK Uprating Complete (2)

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Uprated Pressure (psig)	Current Uprated Length (miles)	% of Original System	Current Exposure (mile-years)
1233	766	24%	3,310
1218	233	7%	720
1088	780	24%	13,890
Note: Figures relate to 3280 miles of UK gas pipeline originally commissioned before 1984		55%	17,920

All figures relate to pipelines originally rated at 1000 psig

From 1985 new UK pipelines were designed for at least 1088 psig (75 bar)

Note that pipelines uprated to 1218 psig were limited to this by the new maximum design factor of 0.80.

Contacts

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