WELLMASTER

WELL PERFORMANCE ANALYTICS

Evaluering av risiko forbundet med løftegass i ringrom og forskellige gassløft barrierer

ESRA seminar, September 3, 2014, Stavanger

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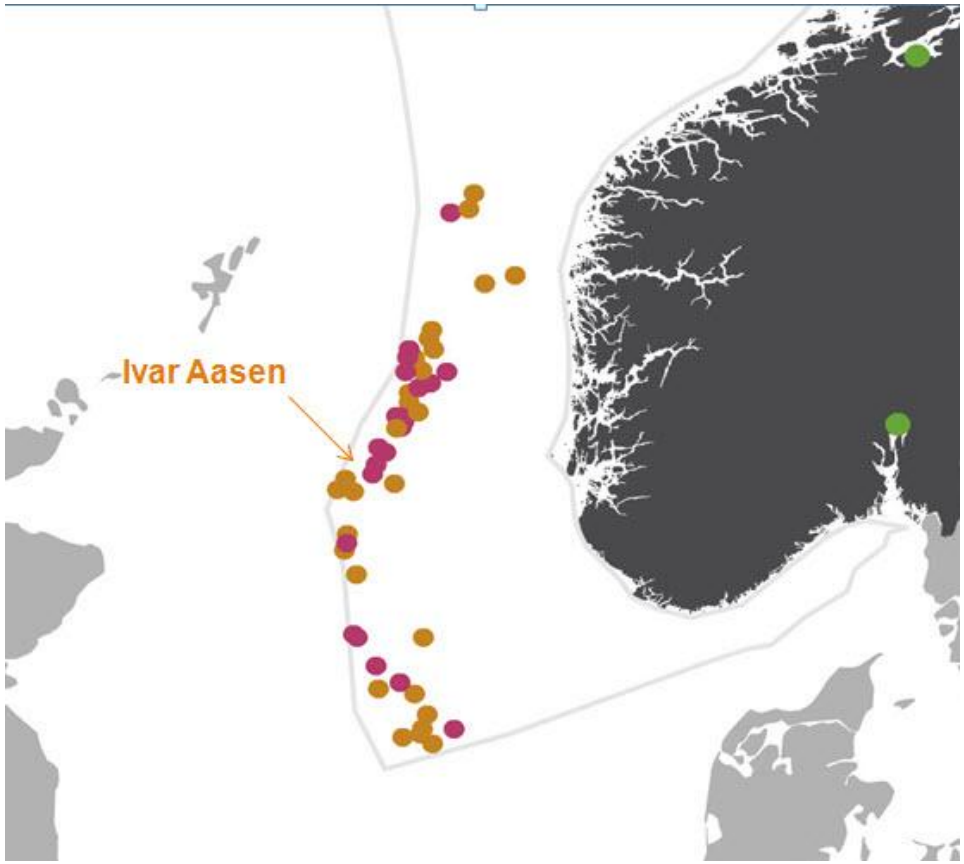
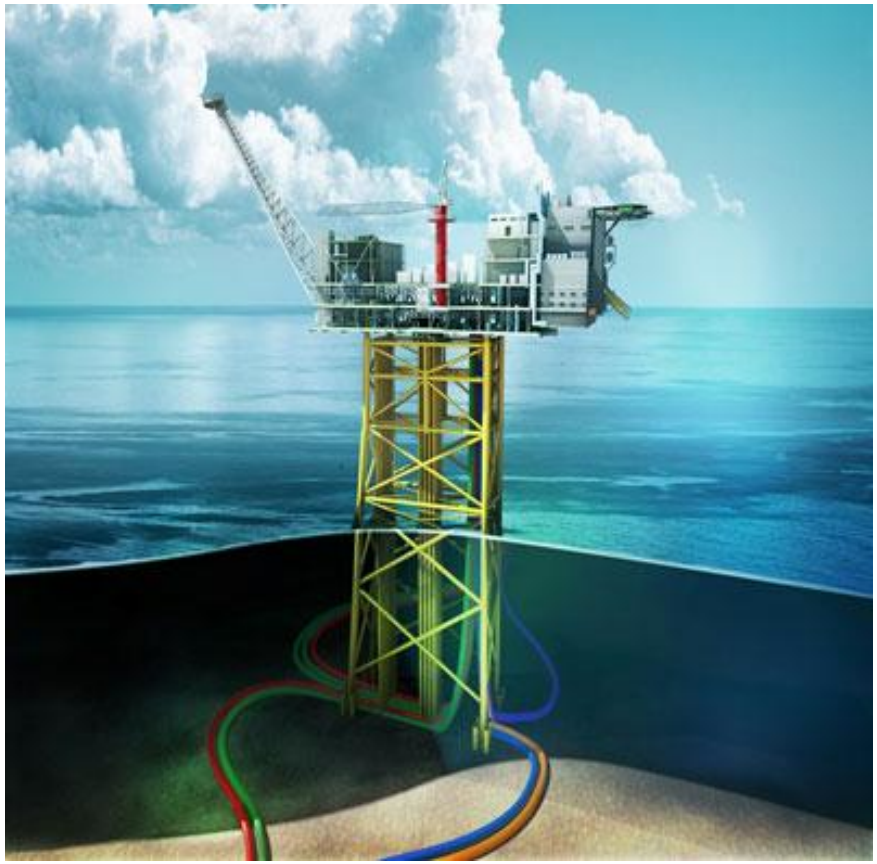
Ivar Aasen



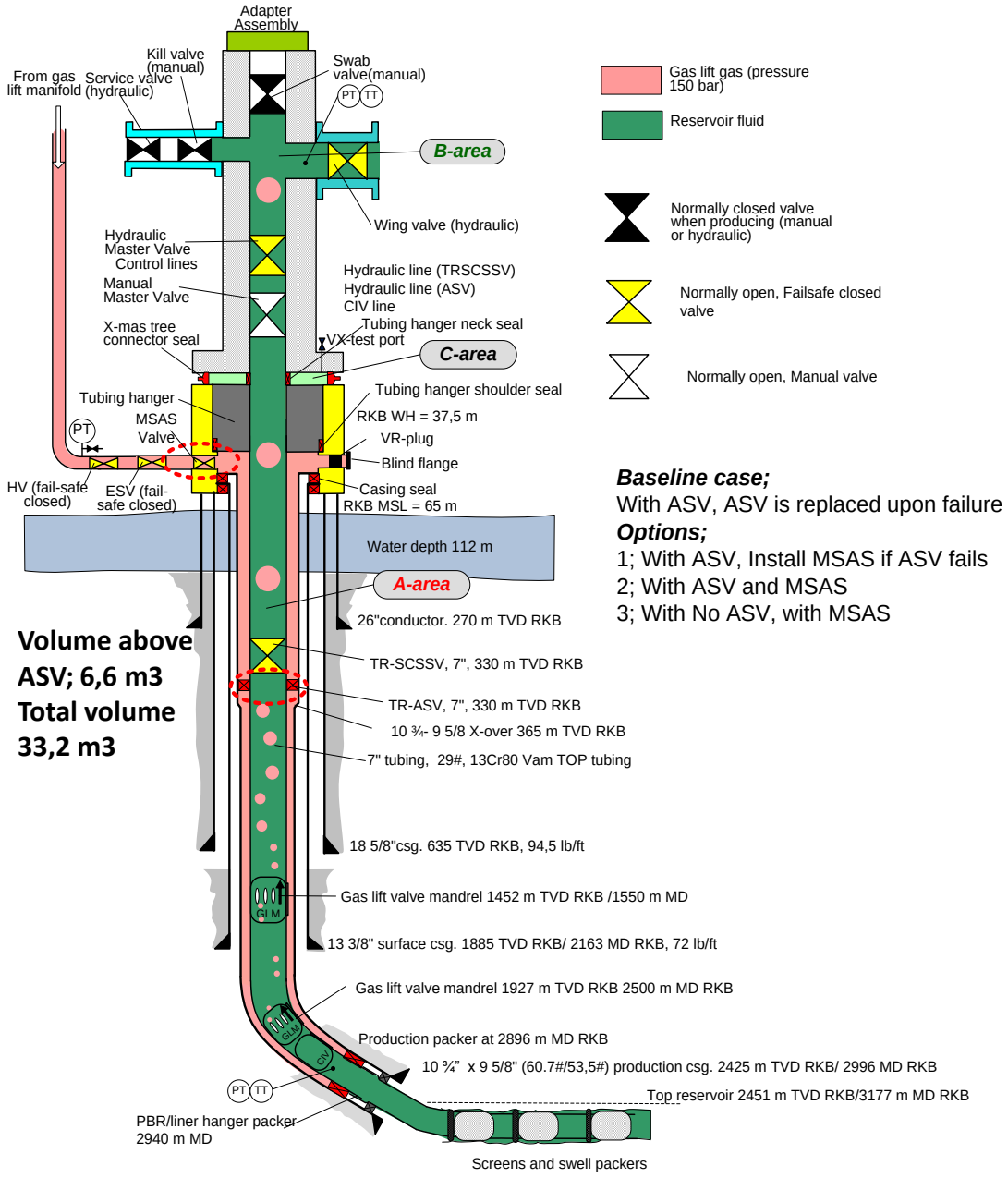


Operator; Det Norske
Production start; late 2016

OBJECTIVE

- To perform an assessment of the total risk of four proposed annulus safety systems for the Ivar Aasen gas lifted wells.
- The relative differences between the four annulus safety systems in terms of how they influence the overall risk level of the platform should be determined.

Ivar Aasen Well, based on DOP-03



Volume above ASV; 6,6 m3
Total volume 33,2 m3

Baseline case;
With ASV, ASV is replaced upon failure
Options;
1; With ASV, Install MSAS if ASV fails
2; With ASV and MSAS
3; With No ASV, with MSAS

Well alternatives

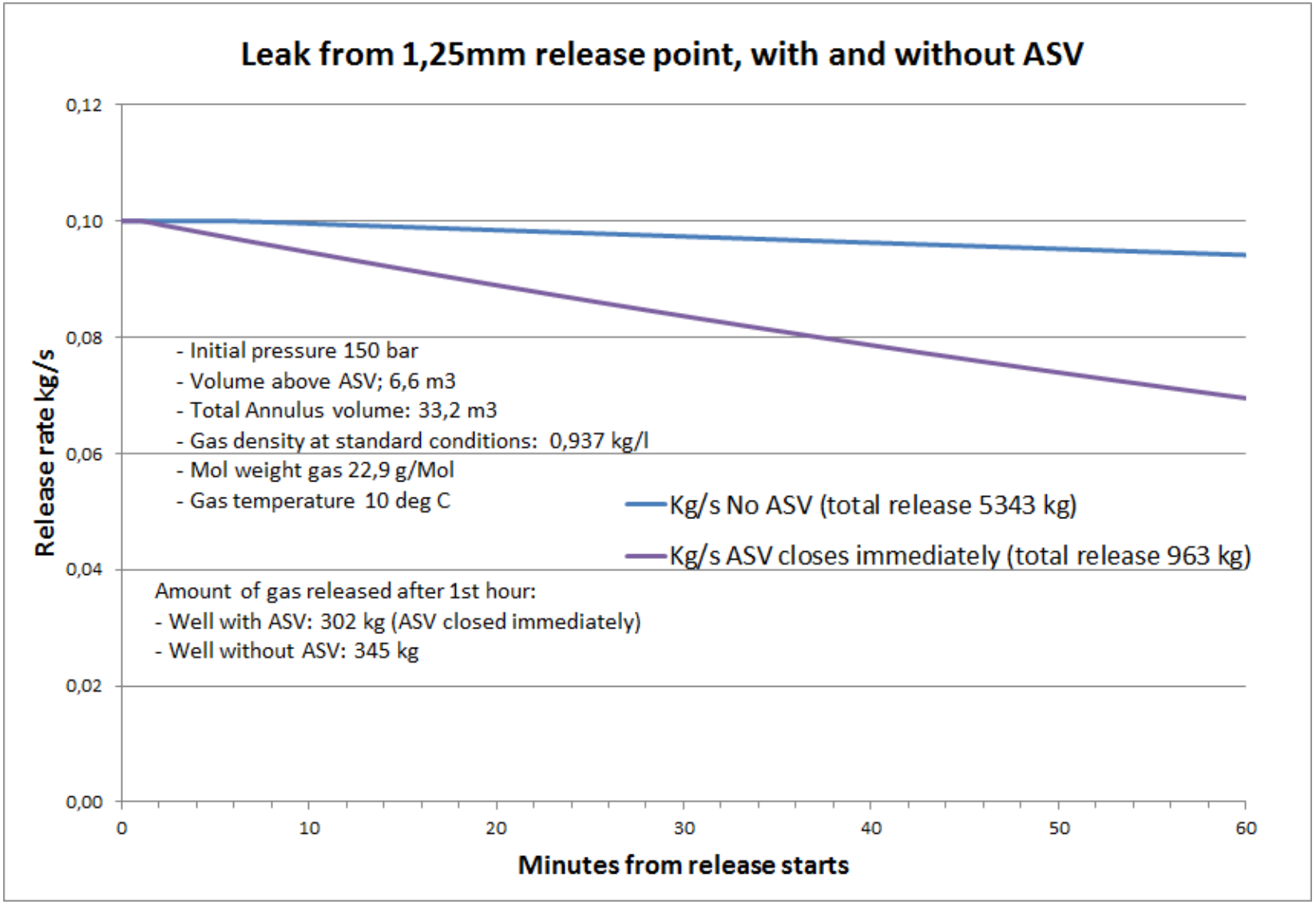
Four well alternatives;

- **Baseline case;** Install an ASV in the well. Replace ASV upon failure
- **Option 1;** Install an ASV in the well and ready the wellhead for a MSAS. An MSAS is installed for strengthening the wellhead barrier in case the ASV fails
- **Option 2** As option 1, but with an MSAS strengthening the wellhead barrier and with GLV's and CIV's qualified as well barrier elements from day one.
- **Option 3** The ASV is not installed in the first place. Strengthen the wellhead with an MSAS and install GLV's and CIV's qualified as well barrier elements from day one.

DESCRIPTION OF WORK

- Four main concepts for gas lift A-annulus barrier were evaluated.
- A review of regulations were carried out
- Experience from gas lift gas incidents were reviewed
  - 1500 US GoM OCS and US Pacific fires 1995 – 2010
  - More than 6500 UK accidents and incident, 1990-2007
- Various leak scenarios from a well annulus with and without an ASV were been evaluated to identify effect on the leakage rate vs. time for the two alternative annulus volumes.
- Review of gas lift equipment reliability. ASVs, GLVs, and MSAS valves were focused on.
- QRA for Ivar Aasen has been reviewed with the objective to establish a basis for quantifying the added risk gas lift gas in the well annulus represent.
- Established reliability model related to leakage of gas lift gas from the annulus and blowout probabilities and analysed probabilities for gas leak and blowout
- The results from the QRA and the gas leak probabilities from the well annulus have been combined to assess the effect of the various well alternatives on the total fatal accident rate (FAR) for Ivar Aasen.

Leak rate vs time example



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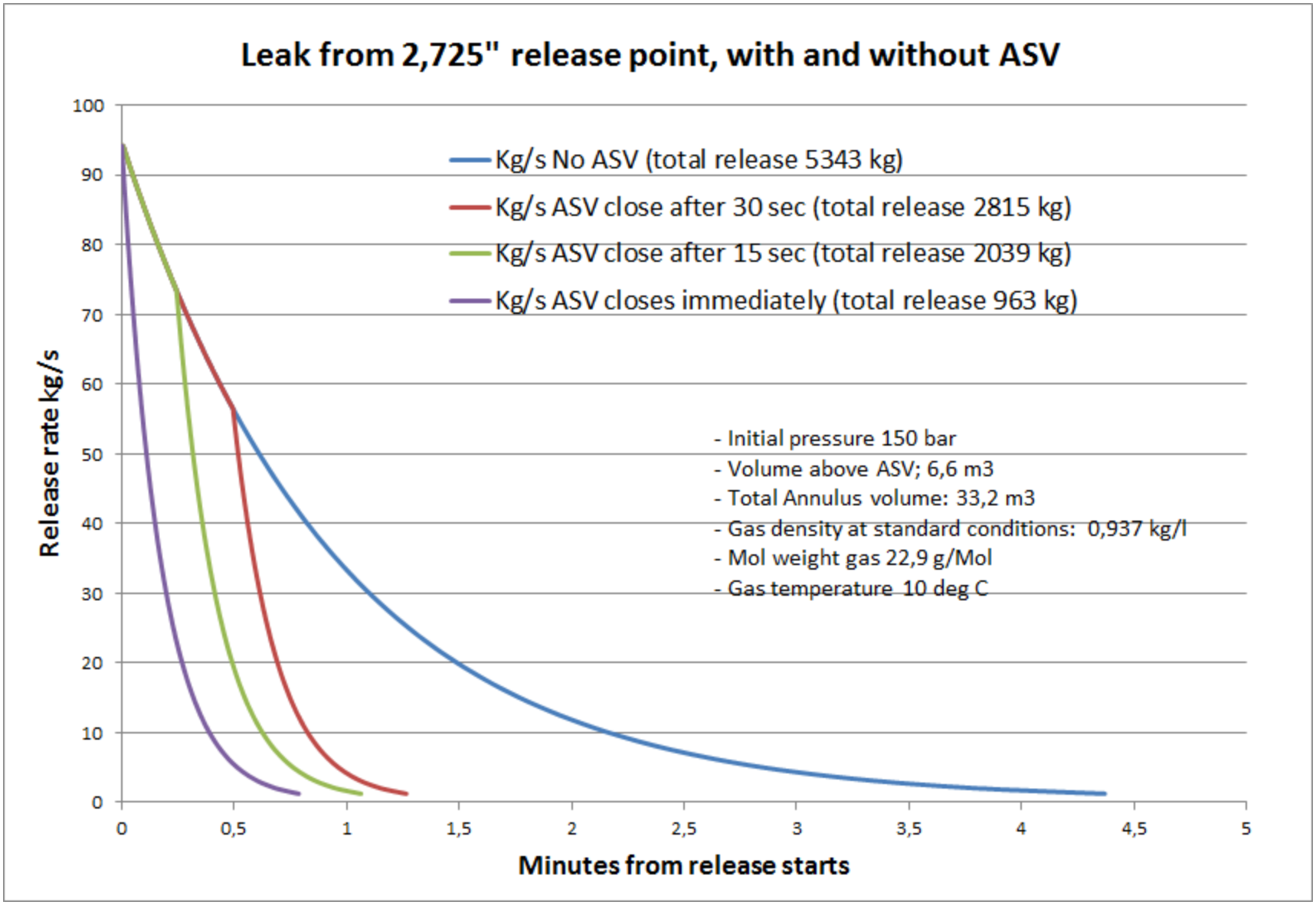
Leak rate vs time example



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Leaks from annulus and effect ASV

- An ASV will only partly protect the surface installation from the gas in the annulus
- There will also be a significant volume of gas above the ASV that also may ignite.
- The first one to five minutes after the release occurs will not be very different for wells with or without an ASV
- For large releases the effect of an ASV will be very dependent on how fast the valve closes.

Key Reliability Data

  - ASV
  - MSAS
  - GLV
- Two out of three must function

- A full workover is required to replace an ASV
- A wireline operation is required to replace a GLV
- Wellhead mechanics and a lubricator tool is required to replace an MSAS

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ASV reliability

Manufacturer	Time period	Years in service	No. of failures	MTTF (years)
Vendor 1	All data	2054	41	50,1
	Valves installed after 01.01.2006	212	3	70,7
Vendor 2	All data	397	47	8,4
	Valves installed after 01.01.2006	137	4	34,3
Vendor 3	All data	423	13	32,5
	Valves installed after 01.01.2006	62,1	2	31,0

Modern ASVs have a fair reliability

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GLV Reliability (installed after January 1, 2006)

Leak category	Manufacturer	Years in service	Re-placed	Wash-ed	Re-tested	Still down-hole	Un-known	Total	MTTF (year)	Failure rate per hour
Large (more than 30 times the leak criteria)	Vendor 4	89,20	1	2				3	29,7	3,84E-06
	Vendor 5	228,37							-	
	Other/unknown	7,47							-	
	Total	325,04	1	2				3	108,3	1,05E-06
Medium (10 -30 times the leak criteria)	Vendor 4	89,20		1		1		2	44,6	2,56E-06
	Vendor 5	228,37	4	2				6	38,1	3,00E-06
	Other/unknown	7,47							-	
	Total	325,04	4	3		1		8	40,6	2,81E-06
Small – medium (3.34-10 times leak criteria)	Vendor 4	89,20	3	6				9	9,9	1,15E-05
	Vendor 5	228,37	9	14		1	2	26	8,8	1,30E-05
	Other/unknown	7,47								
	Total	325,04	12	20		1		35	9,3	1,23E-05
Very small (1-3,33 times the leak criteria)	Vendor 4	89,20	5	12		1		18	5,0	2,30E-05
	Vendor 5	228,37	11	19	1	1	1	33	6,9	1,65E-05
	Other/unknown	7,47	1					1	7,5	1,53E-05
	Total	325,04	17	31		2		52	6,3	1,83E-05
Total all failures		325,04	34	56	1	4	3	98	3,3	3,44E-05

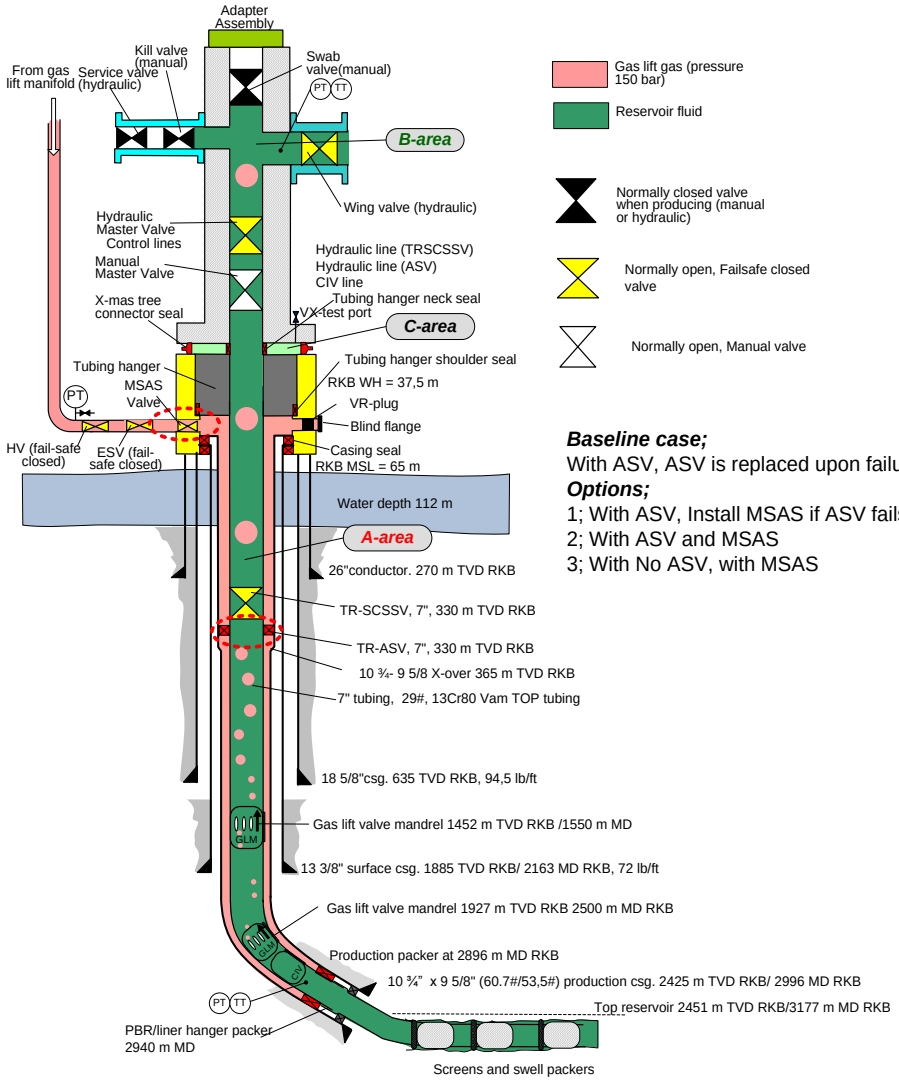
GLVs have a high failure rate, scale is the main problem for barrier qualified valves, wear for conventional valves

GLV reliability comments

- Fifty-two of the failures were observed in 13 wells. The remaining 46 failures were observed in 30 different wells
- Old type GLVs wear out, while new barrier qualified valves scale
- It is believed that GLV design changes and new models will cause them to be better to withstand scaling conditions

Barrier modelling

Ivar Aasen Well, based on DOP-03



Baseline case;
With ASV, ASV is replaced upon failure
Options;
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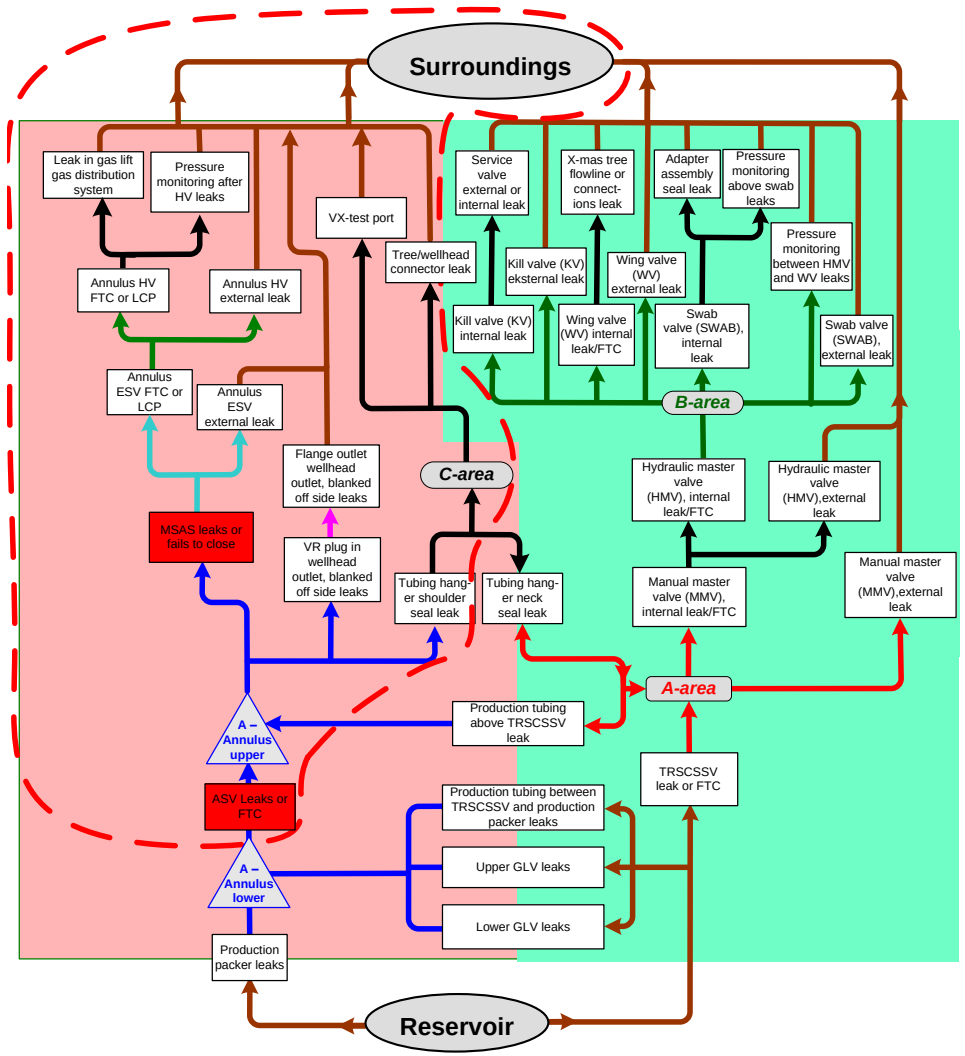
Barrier diagram Ivar Aasen well



Fault tree analyses

- Probability of gas leaks from wellheads with and without MSAS
- Blowout probability for various well designs

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Leak frequency contribution from seven gas lifted annulus on Ivar Aasen wells

Initial leak rate	With MSAS				Without MSAS		
	Freq. per year per 7 wells	MTTL (year)	Distribution	Relative to well without MSAS	Freq. per year per 7 wells	MTTL (year)	Distri-bution
Small leak	6,35E-04	1 576	97,8 %	55,9 %	1,14E-03	880	82,9 %
Medium leak	1,45E-05	69 124	2,2 %	8,0 %	1,82E-04	5 509	13,2 %
Large leak	0,00E+00	-	0,0 %	0,0 %	5,27E-05	18 963	3,8 %
Total	6,49E-04	1 541	100,0 %	47,4 %	1,37E-03	730	100,0 %

- The leak probabilities are for leaks that cannot be sealed off by the barriers in the X-mas tree and wellhead.
- This means that for many of the cases there will have been minor releases before the barrier have been activated.
- It can be assumed that medium and large leaks will be detected when they occur and the well will automatically be shut in within seconds.
- For minor leaks the leaks may last for some time before they are discovered by operators or the ESD system.
- Whether the well has an ASV or not will not impact on these releases situations. The initial situation will be the same for a well with or without an ASV.

Effect on Wellhead Area FAR and Installation FAR

Installation FAR contribution from annulus gas releases, assuming no effect of ASV

Leak source	Leak frequency vs. leak size				Contribution to installation FAR vs. leak size			
	Small	Medium	Large	Total	Small	Medium	Large	Total
Wellhead Cellar Deck	1,70E-01	1,50E-02	3,00E-02	2,15E-01	0,154	0,216	1,17	1,54
Wellhead Intermediate Deck	1,30E-02	1,10E-03	1,00E-03	1,51E-02	0,004	0,006	0,03	0,04
Total	1,83E-01	1,61E-02	3,10E-02	2,30E-01	0,158	0,222	1,2	1,58
Increase from GL with MSAS	6,35E-04	1,45E-05	0,00E+00	6,49E-04	0,000548	0,000199	0,000000	0,000562
Increase from GL without MSAS	1,14E-03	1,82E-04	5,27E-05	1,37E-03	0,000981	0,002503	0,002041	0,001162

Relative increase in the wellhead area FAR contribution from annulus gas releases, assuming no effect of ASV

Leak source	Contribution to total FAR				Relative installation wellhead area FAR Increase			
	Small	Medium	Large	Total	Small	Medium	Large	Total
Wellhead Cellar Deck	0,154	0,216	1,17	1,54				97,5%
Wellhead Intermediate Deck	0,004	0,006	0,03	0,04				2,5%
Total	0,158	0,222	1,2	1,58				100,0%
Increase from GL With MSAS	0,000548	0,000199	0,000000	0,000562	0,347 %	0,090 %	0,000 %	0,437 %
Increase from GL Without MSAS	0,000981	0,002503	0,002041	0,001162	0,621 %	1,128 %	0,170 %	1,918 %

The wellhead area represents 11,3% of the installation FAR.
The increase to the installation FAR would be;

- 0,049% for the alternative with an MSAS and
- 0,22% for the alternative without an MSAS.

Gas lift gas in annulus ignition with ASV or with MSAS

If assuming;

- gas lift gas leaks from annulus with MSAS and without ASV will last for a long period and may ignite immediately or delayed
- gas lift gas leaks from annulus with ASV and without MSAS will last for a short time period and may only ignite immediately
- Ignition probabilities from QRA

Type of hydrocarbon	Immediate Ignition Probability			Delayed Ignition Probability		
	Small	Medium	Large	Small	Medium	Large
Process Gas	0,27 %	1,28 %	2,80 %	0,11 %	0,55 %	1,20 %
Process liquid	0,15 %	0,37 %	0,93 %	0,06 %	0,16 %	0,40 %

- And combines with leak probability from wells with and without an ASV
- NEXT SLIDE RESULTS

Comparison ignition frequency

	Annulus leak frequency, ignition probability vs. leak size and annulus protection								
	Small			Medium			Large		
	Leak frequency	Ignition proba-bility	Ignited incident frequency	Leak frequency	Ignition proba-bility	Ignited incident frequency	Leak frequency	Ignition proba-bility	Ignited incident frequency
Increase from GL with MSAS, no ASV	6,35E-04	0,38 %	2,41E-06	1,45E-05	1,83 %	2,65E-07	0,00E+00	4,00 %	0,00E+00
Increase from GL with ASV, no MSAS	1,14E-03	0,27 %	3,01E-06	1,82E-04	1,28 %	2,32E-06	5,27E-05	2,80 %	1,48E-06

- The probability of an ignited leak from a gas lifted annulus release is low for all cases
- This is also confirmed by the incident data from UK and US
- Bear in mind that there will be uncertainties in these types of calculations. The absolute figures will be uncertain, but relative difference between the two alternatives will be real with the MSAS alternative as the preferred
- The results will be valid for the Ivar Aasen installation with
  - the selected X-mas tree and wellhead layout
  - conductors protected by the structure

Ranked well alternatives

Well alternatives ranked with respect to total risk, the first alternative as the best;

1. Option 2; Both MSAS and ASV from day 1
2. Option 3; Use MSAS no ASV
3. Option 1; Use ASV, replace with MSAS if ASV fails
4. Baseline case; Use ASV, replace by full workover if ASV fails