AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FK11074**
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Project-No.: K70101 Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^*\sqrt{\frac{\rho 1}{1000^*\Delta p}}$	$k_v = \frac{G}{\sqrt{1000^*\rho 1^*\Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^*T1}{\Delta p^*p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^*\Delta p^*p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257p1}\sqrt{\rho_N{}^*T1}$	$k_v = \frac{G}{257p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	Q [m³/h]	18040,71	22762,43	23681,32
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	73000,00	97000,00	100000,00
charge pressure (abs.)	p1 [bar]	5,530	5,87	5,81
discharge pressure (abs.)	p2 [bar]	5,380	5,72	5,66
pressure loss	Δp [bar]	0,150	0,15	0,15
mass flow	G [kg/h]	94389,00	125421,00	129300,00
medium density	ρ1 [kg/m³]	5,232	5,51	5,46
absolute temp. (inlet side)	T1 [K]	366,20	368,80	368,40
spec. volume at p2 and t1	V2 [m³/kg]	0,20	0,19	0,19
spec. volume at p1/2 and t1	V* [m³/kg]	0,38	0,36	0,36

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	3440,18	4448,97	4608,31
travel (%) (first give Kvs-value!)	89,33	95,90	96,80
selected Kvs-value	**Kvs=**	**5222,00**	
valve type	**butterfly valve**		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

0	19.01.2005	Möller	Eichler	Initial Version					
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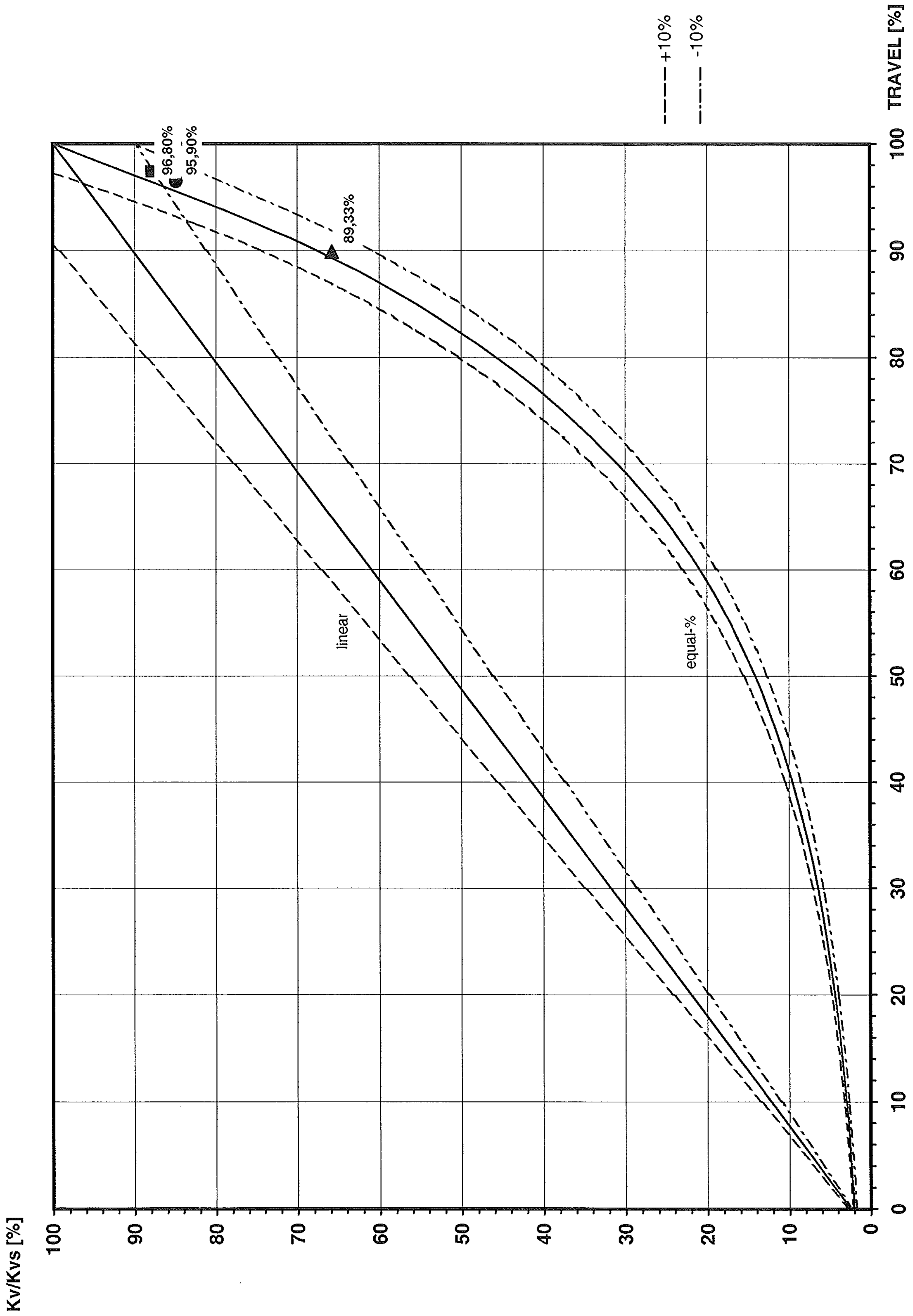
AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FK11074** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FV12005** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^*T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		water		
state		liquid		
standard density		1000,0000 kg/m³		
volume flow	Q [m³/h]	15,30	25,11	45,04
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	15,30	25,10	45,01
charge pressure (abs.)	p1 [bar]	9,000	9,00	9,00
discharge pressure (abs.)	p2 [bar]	1,040	1,04	1,04
pressure loss	Δp [bar]	7,960	7,96	7,96
mass flow	G [kg/h]	15300,00	25100,00	45010,00
medium density	$\rho 1$ [kg/m³]	999,800	999,80	999,40
absolute temp. (inlet side)	T1 [K]	285,30	284,80	288,10
spec. volume at p2 and t1	V2 [m³/kg]	0,00	0,00	0,00
spec. volume at p1/2 and t1	V* [m³/kg]	0,00	0,00	0,00

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

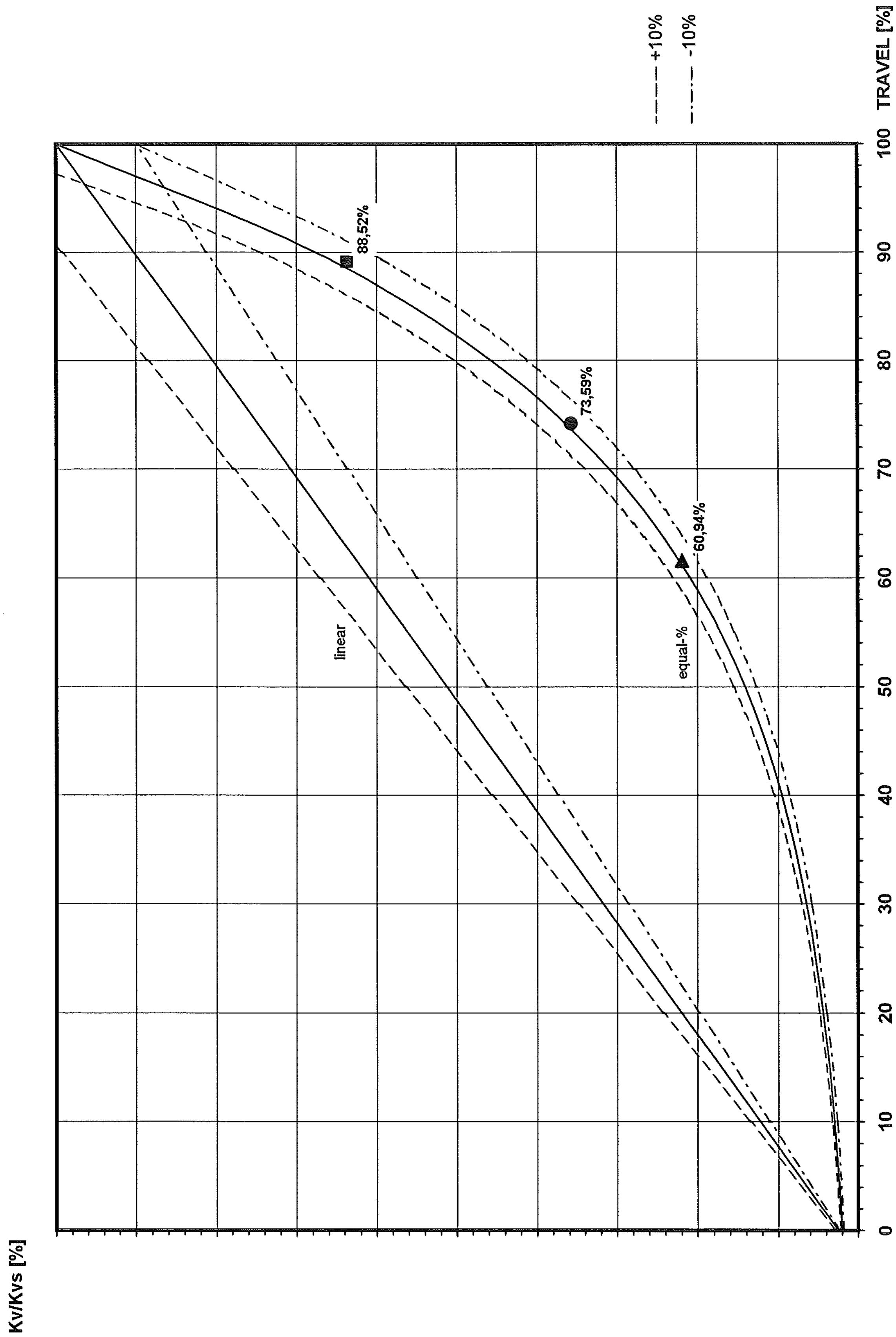
RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	5,42	8,90	15,96
Kv_tot	5,42	8,90	15,96
travel (%) (first give Kvs-value!)	60,94	73,59	88,52
selected Kvs-value	**Kvs=**	**25,00**	
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FV12005** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



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0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FK13006** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		water		
state		liquid		
standard density		1000,0000 kg/m³		
volume flow	Q [m³/h]	19,93	29,66	29,70
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	19,92	29,65	29,69
charge pressure (abs.)	p1 [bar]	9,000	9,00	9,00
discharge pressure (abs.)	p2 [bar]	7,461	7,78	7,71
pressure loss	Δp [bar]	1,539	1,22	1,29
mass flow	G [kg/h]	19920,00	29654,00	29691,00
medium density	ρ1 [kg/m³]	999,400	999,80	999,80
absolute temp. (inlet side)	T1 [K]	288,10	284,80	285,30
spec. volume at p2 and t1	V2 [m³/kg]	0,00	0,00	0,00
spec. volume at p1/2 and t1	V* [m³/kg]	0,00	0,00	0,00

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	16,06	26,87	26,16
Kv_tot	16,06	26,87	26,16
travel (%) (first give Kvs-value!)	28,44	41,59	40,91
selected Kvs-value	Kvs=	**264,00**	
valve type	butterfly valve		

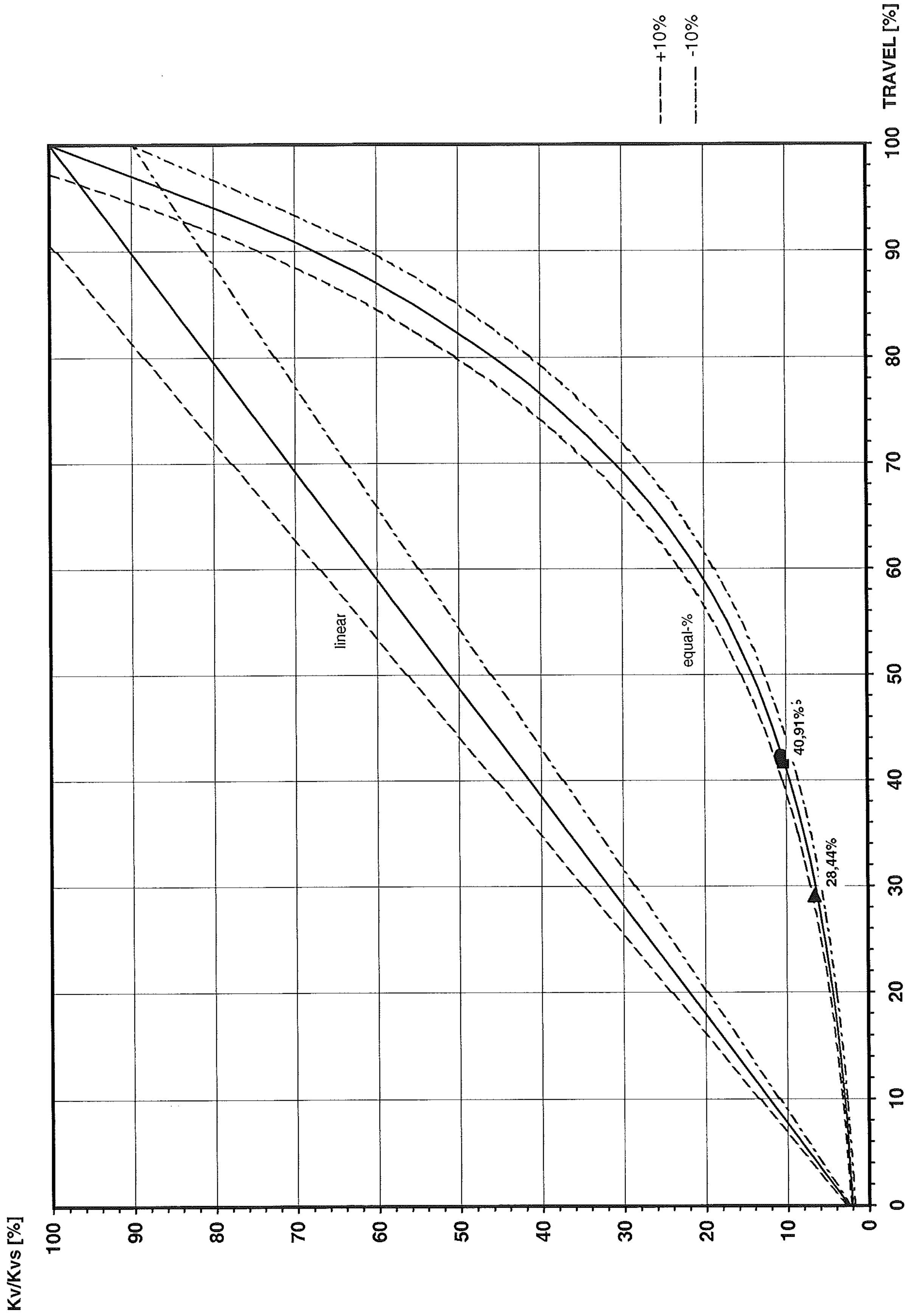
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FK13006** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

FK13006_calc.XLS SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FK13007** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		water		
state		liquid		
standard density		1000,0000 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	210,17	210,17	210,17
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	210,00	210,00	210,00
charge pressure (abs.)	**p1 [bar]**	8,000	8,00	8,00
discharge pressure (abs.)	**p2 [bar]**	6,480	6,80	6,73
pressure loss	**Δp [bar]**	1,520	1,20	1,27
mass flow	**G [kg/h]**	210000,00	210000,00	210000,00
medium density	**ρ1 [kg/m³]**	999,200	999,20	999,20
absolute temp. (inlet side)	**T1 [K]**	288,10	284,80	285,30
spec. volume at p2 and t1	**V2 [m³/kg]**	0,00	0,00	0,00
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,00	0,00	0,00

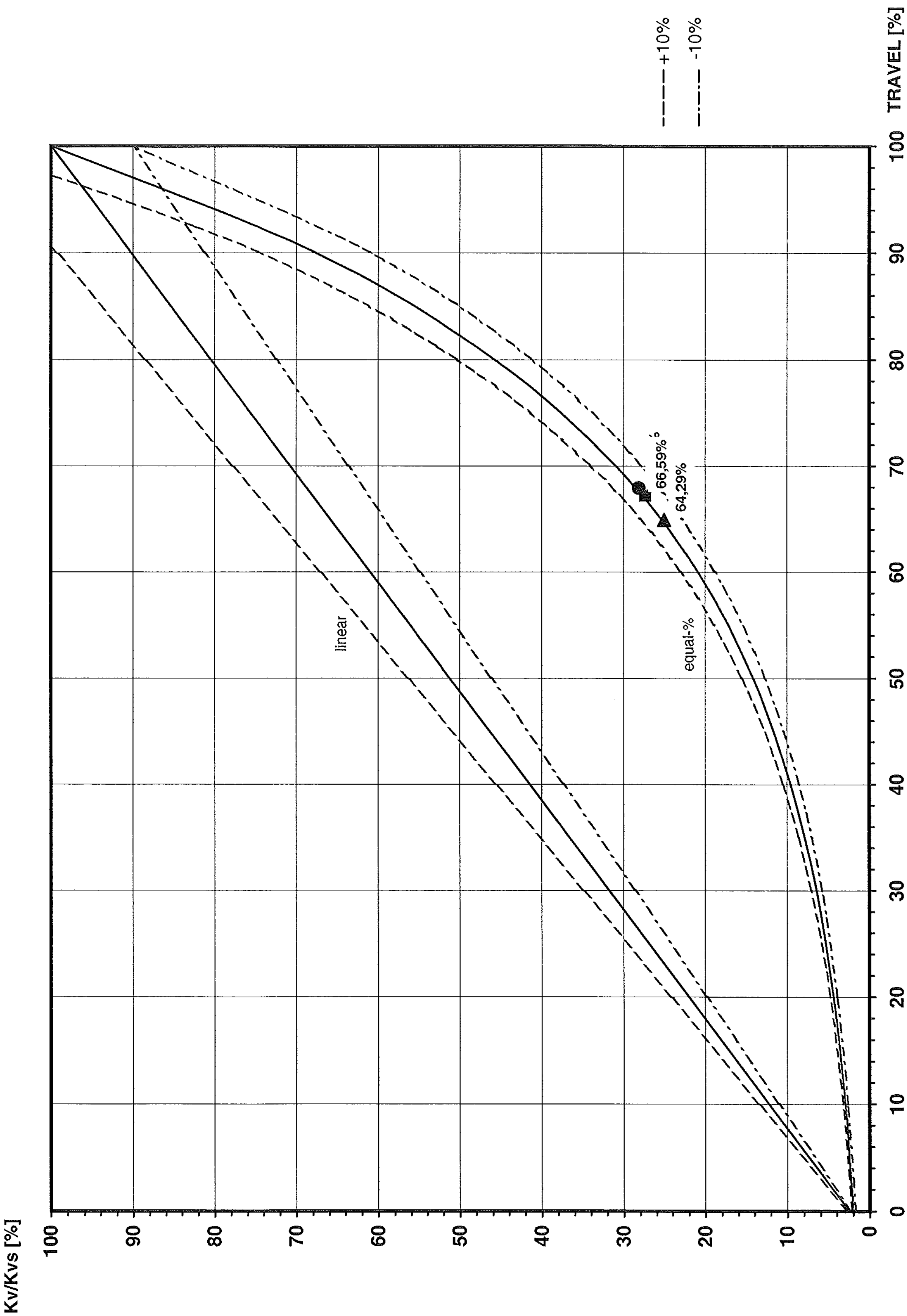
	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	170,41	191,80	186,44
Kv_tot	170,41	191,80	186,44
travel (%) (first give Kvs-value!)	64,29	67,31	66,59
selected Kvs-value	**Kvs=**	**689,00**	
valve type	**butterfly valve**		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES		
gas	**chemical symbol**	**density ρ_N kg/m³**
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.:	**FK13007**
		Project No.:	K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page:	of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

FK13007_calc.XLS

SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **LK13008** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1}\sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		water		
state		liquid		
standard density		1000,0000 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	230,81	240,84	240,89
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	230,23	240,10	240,12
charge pressure (abs.)	**p1 [bar]**	5,530	5,87	5,81
discharge pressure (abs.)	**p2 [bar]**	2,000	2,00	2,00
pressure loss	**Δp [bar]**	3,530	3,87	3,81
mass flow	**G [kg/h]**	230234,00	240095,00	240123,00
medium density	**ρ1 [kg/m³]**	997,500	996,90	996,80
absolute temp. (inlet side)	**T1 [K]**	297,50	300,00	300,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,00	0,00	0,00
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,00	0,00	0,00
		RESULTS		
		case 1	**case 2**	**case 3**
pressure gradient		supercritical	supercritical	supercritical
flash (%)				
Kv_flash				
Kv_liquid		122,69	122,24	123,22
Kv_tot		122,69	122,24	123,22
travel (%) (first give Kvs-value!)		40,73	40,63	40,83
selected Kvs-value		**Kvs=**	**1247,00**	
valve type		**butterfly valve**		

STANDARD DENSITIES OF COMMON GASES		
gas	**chemical symbol**	**density ρ_N** kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LK13008** Project No.: K70101
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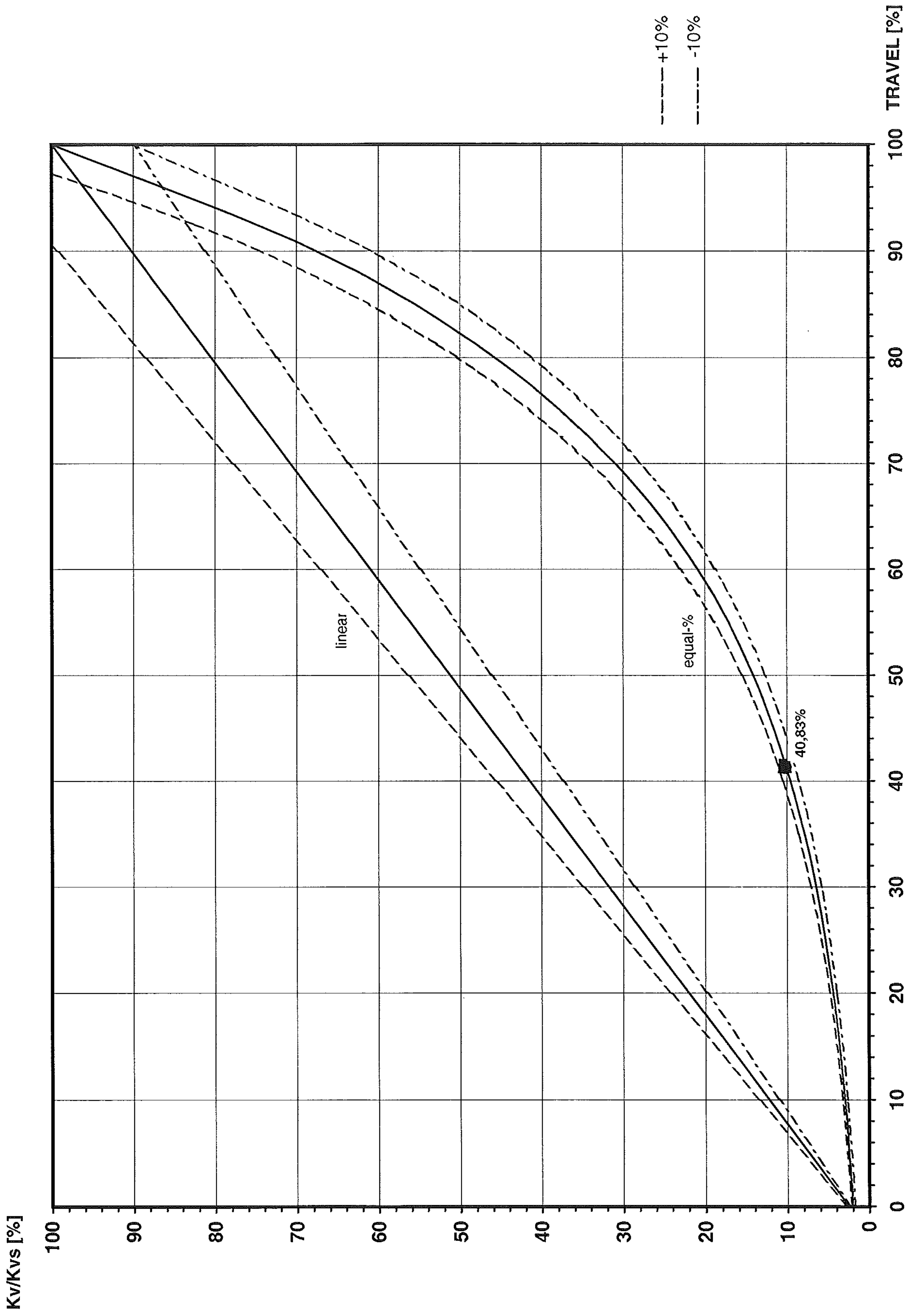


0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT13013** Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: DCAC	

SERVICE WATER

Temperature	T =	**27**	°C
Service Density	ρ_M =	**996,9**	kg/m³

GAS ABOVE LIQUID AIR

Temperature	T =	**14**	°C
Pressure (abs.)	P =	**5,82**	bar
Gas Density	ρ_G =	**7,07**	kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES SILICONE OIL

Ambient Temperature	T_U =	**15**	°C
Filling Density	ρ_F =	**960**	kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1)	a =		mm
Distance between L+ and L- Nozzle (see fig. 2)	e =	**2100**	mm
From L+ Nozzle to 0% Level H1	b =	**0**	mm
From L+ Nozzle to 100% Level H2	d =	**2100**	mm
From H1 to H2	c =	**2100**	mm

CALCULATION ACCORDING TO

○ Fig. 1

$$P_{H1}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

$$P_{H2}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

Diff. Press. 0% **P_{H1} =** **mbar**

Diff. Press. 100% **P_{H2} =** **mbar**

Span **P_{H2-H1} =** **mbar**

◉ Fig. 2

$$P_{H1}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm}+\frac{\rho_G}{kg/m^3}\cdot\frac{(e-b)}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

$$P_{H2}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm}+\frac{\rho_G}{kg/m^3}\cdot\frac{(e-d)}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

Diff. Press. 0% **P_{H1} =** **-196,246** **mbar**

Diff. Press. 100% **P_{H2} =** **7,599** **mbar**

Span **P_{H2-H1} =** **203,845** **mbar**

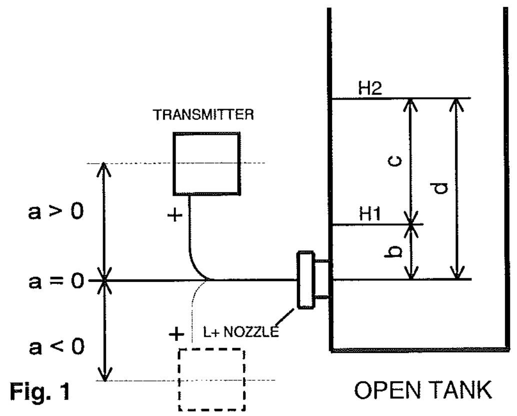


Fig. 1 OPEN TANK

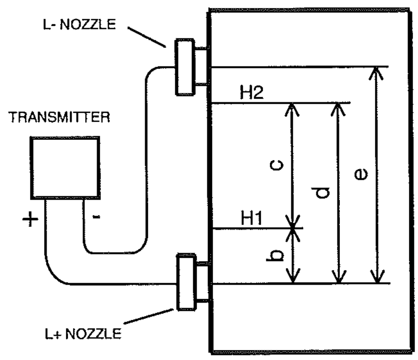


Fig. 2 CLOSED TANK

REMARKS

0	17.03.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **LK1403**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value

	pressure gradient	liquids: flow (m³/h)	liquids: flow (kg/h)	gases: flow (m³/h)	gases: flow (kg/h)	steam: flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		water		
state		liquid		
standard density		1000,0000 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	Q [m³/h]	20,02	30,03	
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	20,00	30,00	
charge pressure (abs.)	p1 [bar]	4,000	4,00	
discharge pressure (abs.)	p2 [bar]	2,970	2,97	
pressure loss	Δp [bar]	1,030	1,03	
mass flow	G [kg/h]	20000,00	30000,00	
medium density	ρ1 [kg/m³]	999,100	999,10	
absolute temp. (inlet side)	T1 [K]	289,10	289,10	
spec. volume at p2 and t1	V2 [m³/kg]	0,00	0,00	
spec. volume at p1/2 and t1	V* [m³/kg]	0,00	0,00	

	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	
flash (%)			
Kv_flash			
Kv_liquid	19,72	29,58	
Kv_tot	19,72	29,58	
travel (%) (first give Kvs-value!)	33,68	44,05	
selected Kvs-value	**Kvs=**	**264,00**	
valve type	**butterfly valve**		

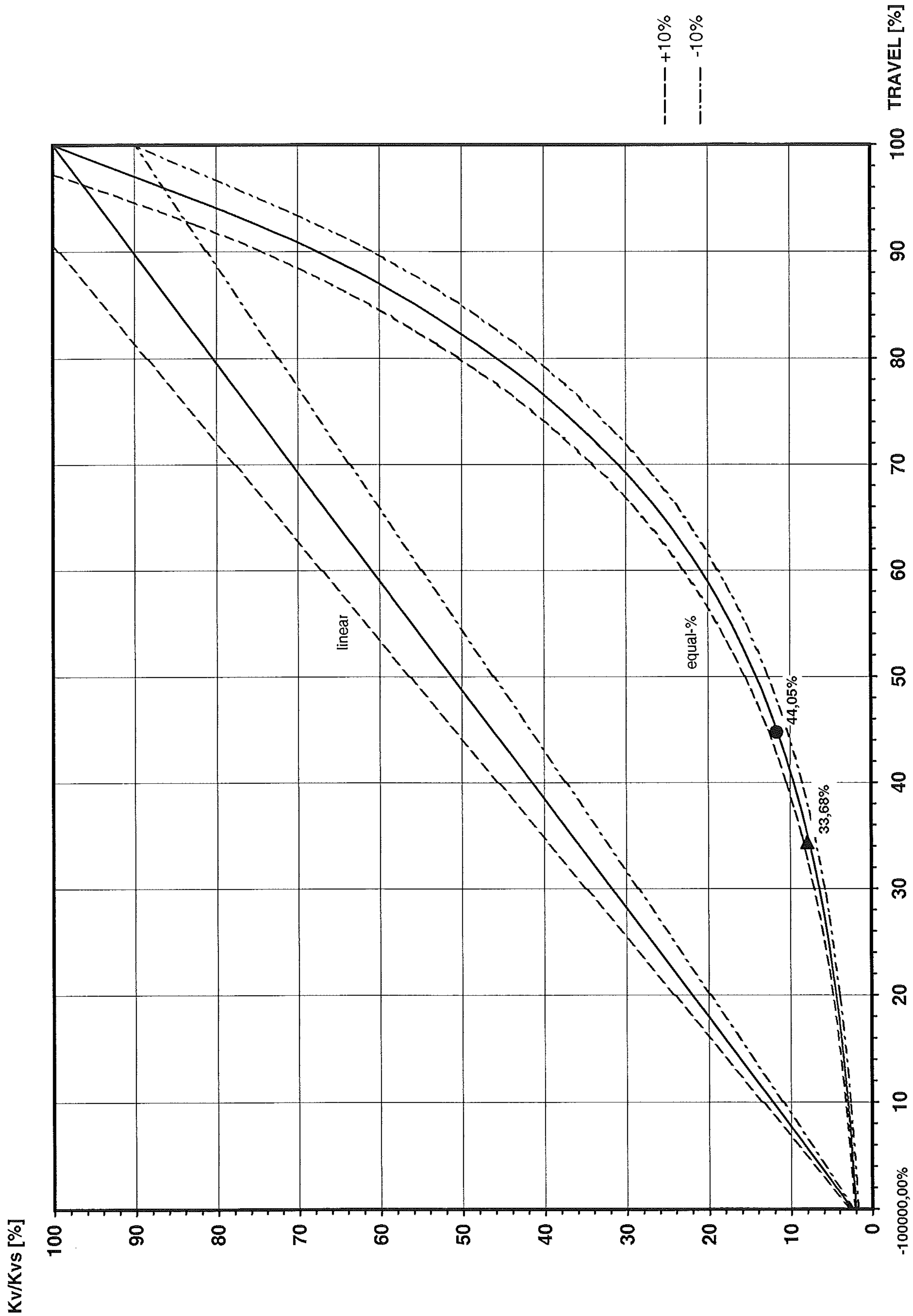
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LK1403** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT14003** Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: CHILL TOWER	

SERVICE WATER

Temperature	$T =$ **10,6**	°C
Service Density	$\rho_M =$ **999,6**	kg/m³

GAS ABOVE LIQUID UN2

Temperature	$T =$ **16,1**	°C
Pressure (abs.)	$P =$ **1,01**	bar
Gas Density	$\rho_G =$ **1,175**	kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES SILICONE OIL

Ambient Temperature	$T_U =$ **15**	°C
Filling Density	$\rho_F =$ **960**	kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1)	$a =$	mm
Distance between L+ and L- Nozzle (see fig. 2)	$e =$ **2100**	mm
From L+ Nozzle to 0% Level H1	$b =$ **0**	mm
From L+ Nozzle to 100% Level H2	$d =$ **2100**	mm
From H1 to H2	$c =$ **2100**	mm

CALCULATION ACCORDING TO

○ Fig. 1

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{b}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{a}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{d}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{a}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

Diff. Press. 0%	$P_{H1} =$		**mbar**
Diff. Press. 100%	$P_{H2} =$		**mbar**
Span	$P_{H2-H1} =$		**mbar**

◉ Fig. 2

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{b}{mm} + \frac{\rho_G}{kg/m^3} \cdot \frac{(e-b)}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{e}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{d}{mm} + \frac{\rho_G}{kg/m^3} \cdot \frac{(e-d)}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{e}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

Diff. Press. 0%	$P_{H1} =$	**-197,460**	**mbar**
Diff. Press. 100%	$P_{H2} =$	**8,155**	**mbar**
Span	$P_{H2-H1} =$	**205,615**	**mbar**

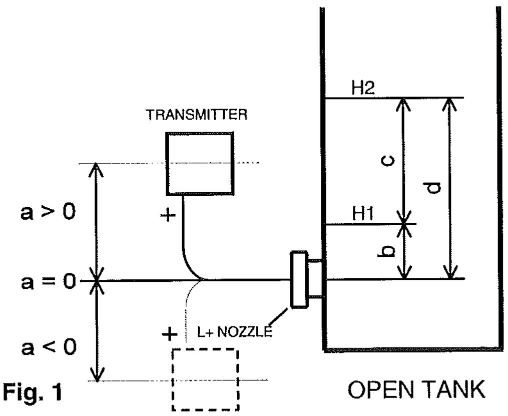


Fig. 1 OPEN TANK

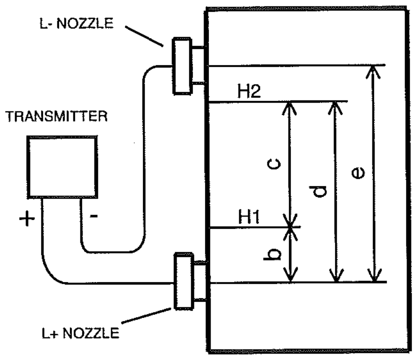


Fig. 2 CLOSED TANK

REMARKS

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.03.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE — Air Liquide AGS GmbH	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **TV14010**
		Project-No.: K70101
	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		water		
state		liquid		
standard density		1000,0000 kg/m³		
		case 1	case 2	case 3
volume flow	Q [m³/h]	20,05	30,09	45,15
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	20,00	30,00	45,01
charge pressure (abs.)	p1 [bar]	5,530	5,87	5,81
discharge pressure (abs.)	p2 [bar]	2,967	2,97	2,97
pressure loss	Δp [bar]	2,563	2,90	2,84
mass flow	G [kg/h]	20000,00	30000,00	45010,00
medium density	$\rho 1$ [kg/m³]	997,500	996,90	996,80
absolute temp. (inlet side)	T1 [K]	297,50	300,00	300,10
spec. volume at p2 and t1	V2 [m³/kg]	0,00	0,00	0,00
spec. volume at p1/2 and t1	V* [m³/kg]	0,00	0,00	0,00

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	12,51	17,63	26,73
Kv_tot	12,51	17,63	26,73
travel (%) (first give Kvs-value!)	59,92	68,70	79,33
selected Kvs-value	**Kvs=**	**60,00**	
valve type	globe valve		

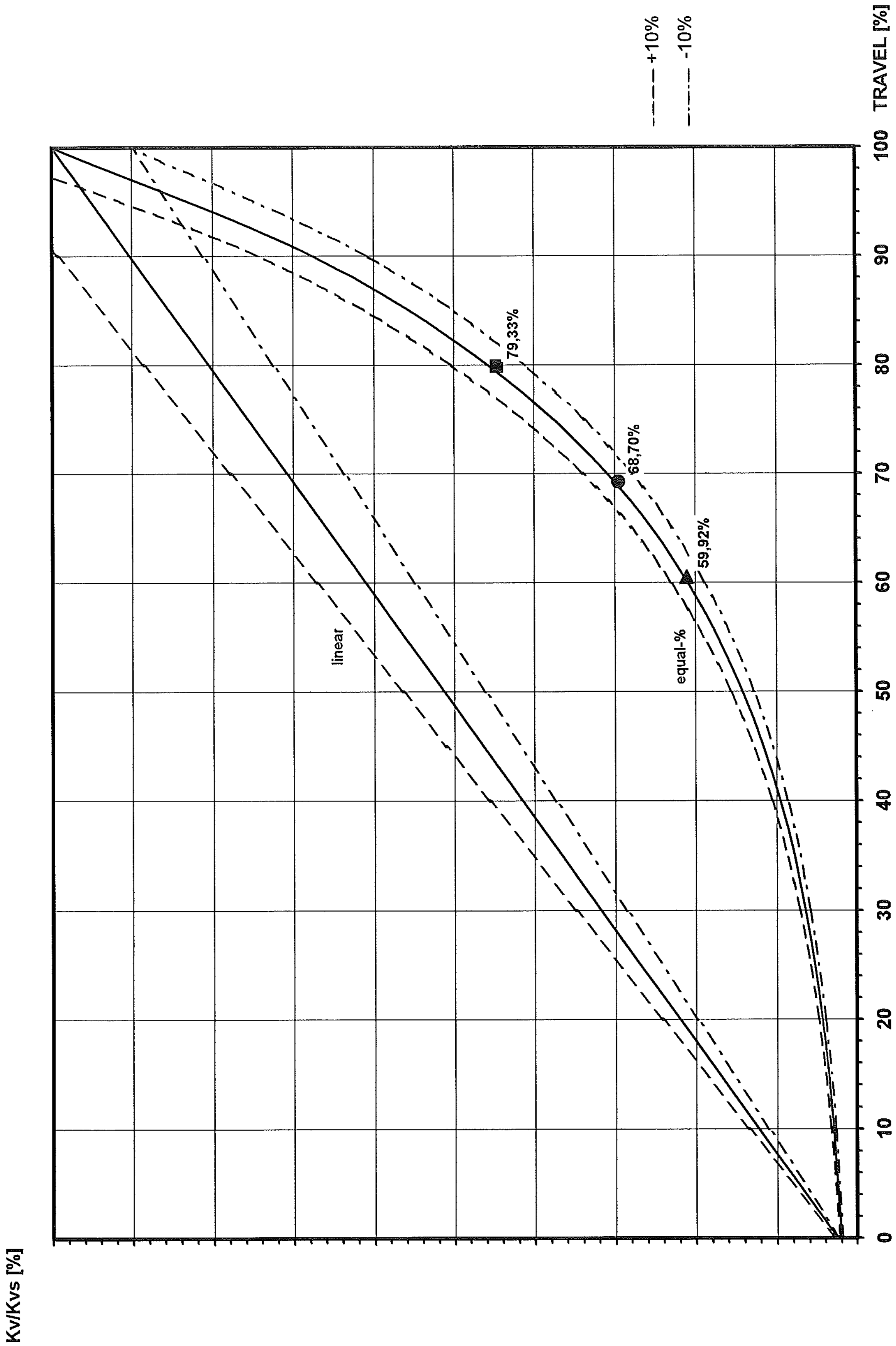
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **TV14010** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15011** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	Q [m³/h]	14111,98	17630,16	18068,83
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	72579,00	96400,00	96954,00
charge pressure (abs.)	p1 [bar]	5,50	5,82	5,72
discharge pressure (abs.)	p2 [bar]	5,50	5,82	5,72
pressure loss	Δp [bar]	0,005	0,00	0,00
mass flow	G [kg/h]	93844,65	124645,20	125361,52
medium density	ρ1 [kg/m³]	6,65	7,07	6,94
absolute temp. (inlet side)	T1 [K]	288,60	287,00	287,70
spec. volume at p2 and t1	V2 [m³/kg]	0,15	0,14	0,14
spec. volume at p1/2 and t1	V* [m³/kg]	0,30	0,28	0,29

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	16456,08	21188,21	21521,80
travel (%) (first give Kvs-value!)	84,65	91,11	91,51
selected Kvs-value	**Kvs=**	**30000,00**	
valve type	**butterfly valve**		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

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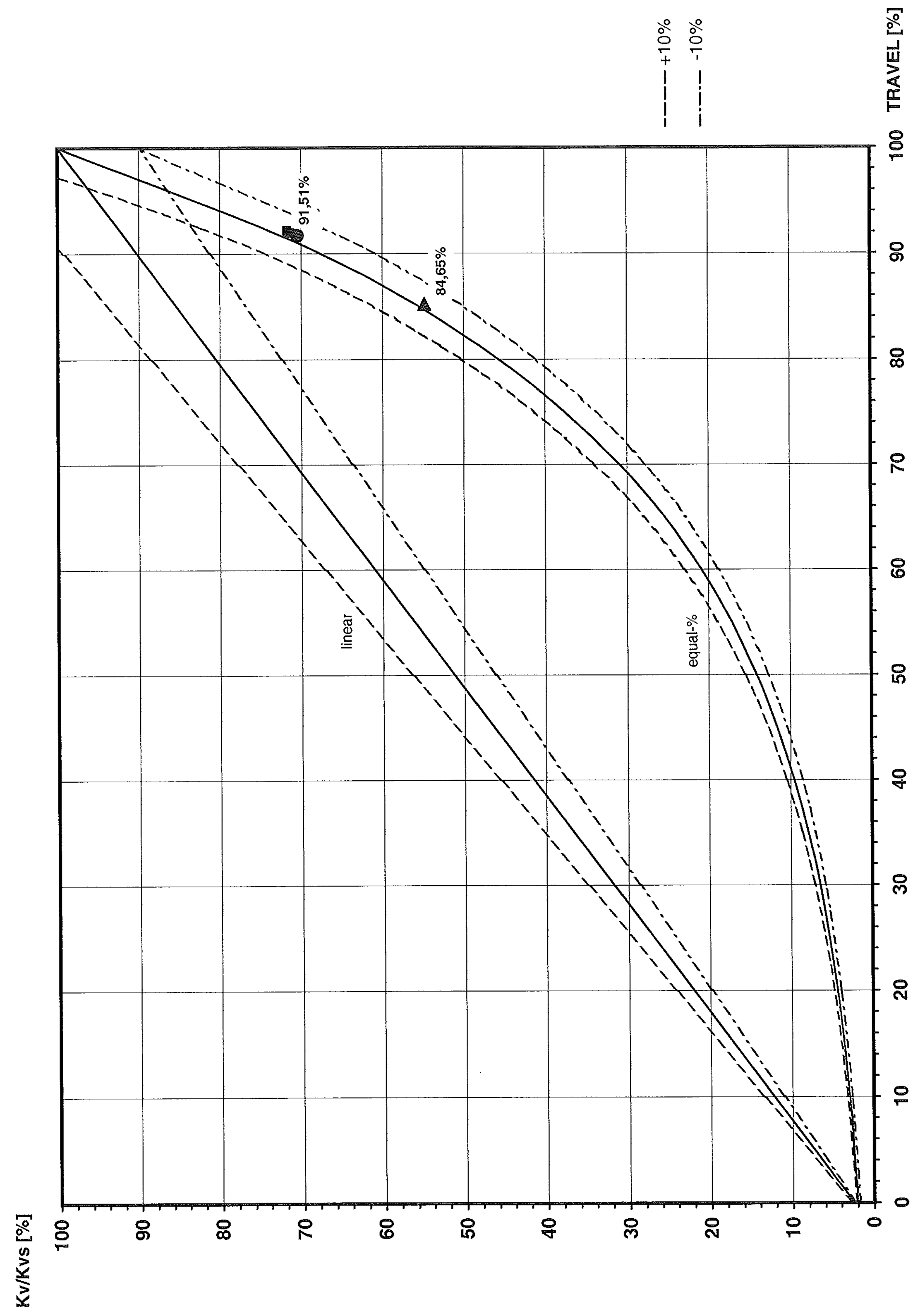
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15011** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15012** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	24411,28	24411,28	24411,28
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	18000,00	18000,00	18000,00
charge pressure (abs.)	**p1 [bar]**	1,02	1,02	1,02
discharge pressure (abs.)	**p2 [bar]**	1,02	1,02	1,02
pressure loss	**Δp [bar]**	0,005	0,01	0,01
mass flow	**G [kg/h]**	22507,20	22507,20	22507,20
medium density	**ρ1 [kg/m³]**	0,92	0,92	0,92
absolute temp. (inlet side)	**T1 [K]**	373,00	373,00	373,00
spec. volume at p2 and t1	**V2 [m³/kg]**	1,09	1,09	1,09
spec. volume at p1/2 and t1	**V* [m³/kg]**	2,17	2,17	2,17

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	10616,23	10616,23	10616,23
travel (%) (first give Kvs-value!)	83,81	83,81	83,81
selected Kvs-value	**Kvs=**	**20000,00**	
valve type	butterfly valve		

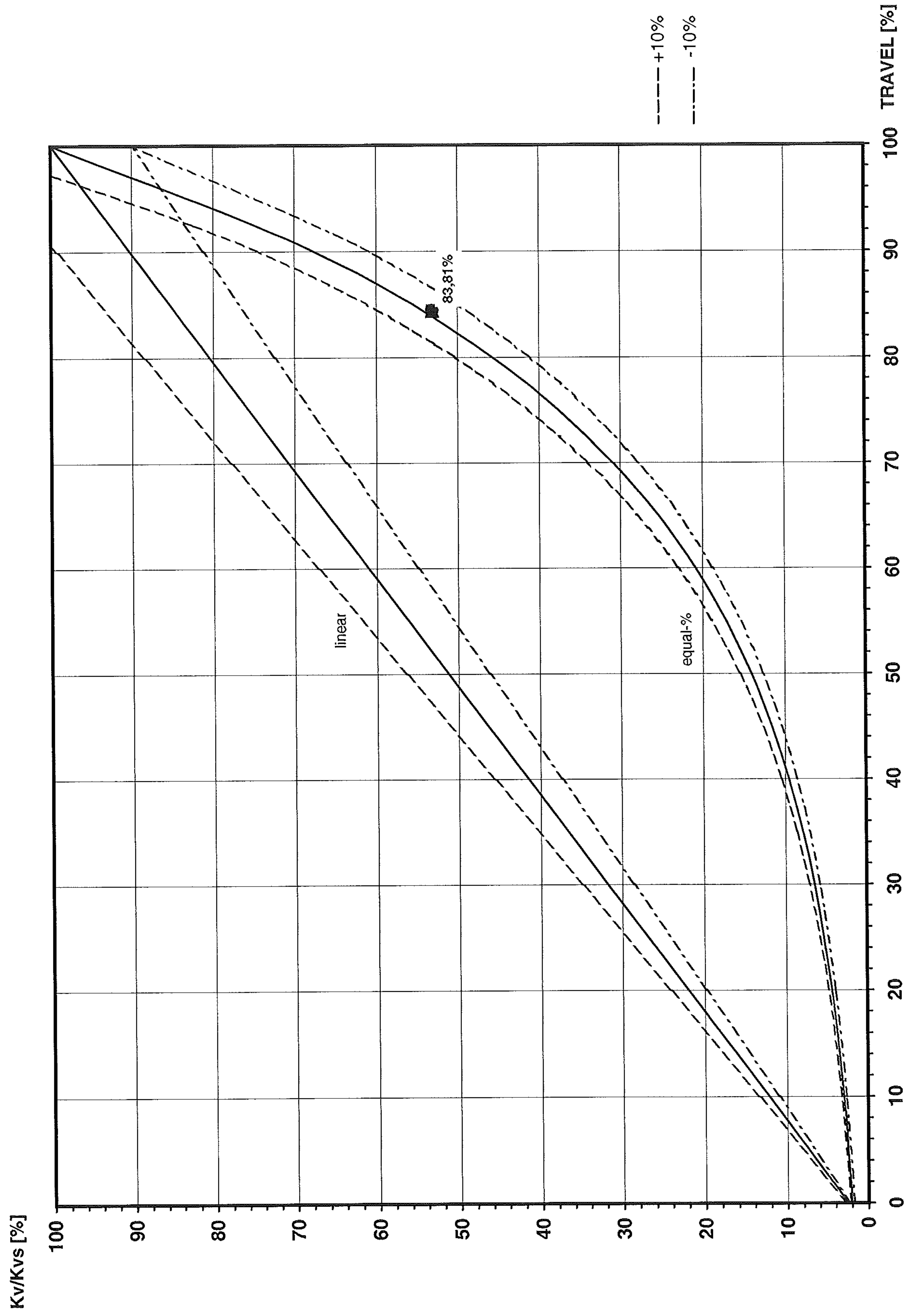
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15012** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



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Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

TAG - No.: **UK15013**

Project-No.: K70101

Project: **ASU No. 9 KOSICE**

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calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	1077,50	1077,50	225,30
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	5500,00	5500,00	1150,00
charge pressure (abs.)	**p1 [bar]**	5,87	3,10	1,06
discharge pressure (abs.)	**p2 [bar]**	1,01	1,01	1,01
pressure loss	**Δp [bar]**	4,857	2,09	0,05
mass flow	**G [kg/h]**	7111,50	7111,50	1486,95
medium density	**ρ1 [kg/m³]**	6,60	6,60	6,60
absolute temp. (inlet side)	**T1 [K]**	288,00	288,00	288,00
spec. volume at p2 and t1	**V2 [m³/kg]**	0,82	0,82	0,82
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,28	0,53	1,56

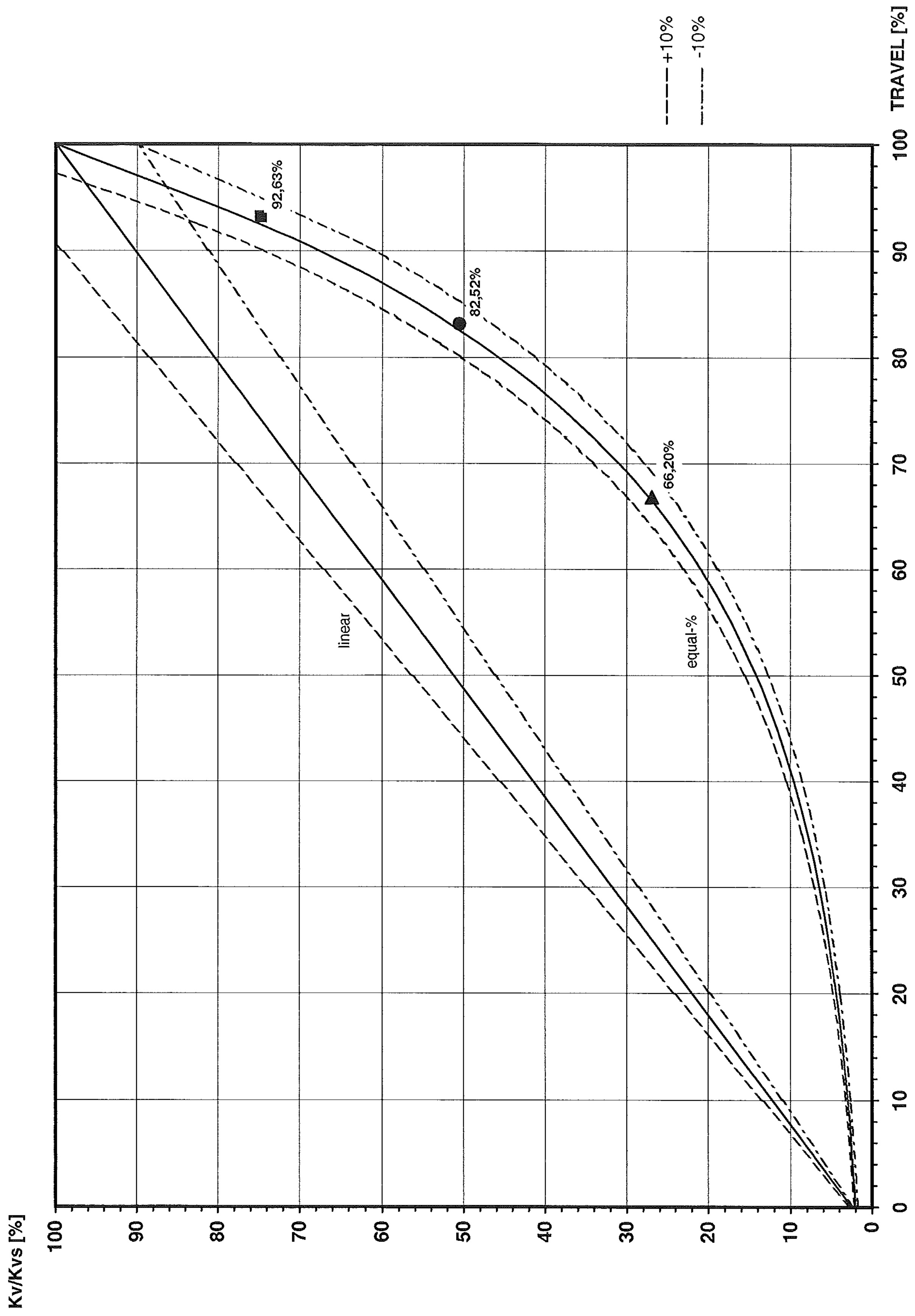
	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	supercritical	supercritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	70,35	133,22	197,87
travel (%) (first give Kvs-value!)	66,20	82,52	92,63
selected Kvs-value	**Kvs=**	**264,00**	
valve type	butterfly valve		

STANDARD DENSITIES OF COMMON GASES		
gas	**chemical symbol**	**density ρ_N kg/m³**
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15013** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	# Specification Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15014** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	22643,06	22643,06	22643,06
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	18000,00	18000,00	18000,00
charge pressure (abs.)	**p1 [bar]**	1,02	1,02	1,02
discharge pressure (abs.)	**p2 [bar]**	1,02	1,02	1,02
pressure loss	**Δp [bar]**	0,005	0,01	0,01
mass flow	**G [kg/h]**	22507,20	22507,20	22507,20
medium density	**ρ1 [kg/m³]**	0,99	0,99	0,99
absolute temp. (inlet side)	**T1 [K]**	373,00	373,00	373,00
spec. volume at p2 and t1	**V2 [m³/kg]**	1,09	1,09	1,09
spec. volume at p1/2 and t1	**V* [m³/kg]**	2,17	2,17	2,17

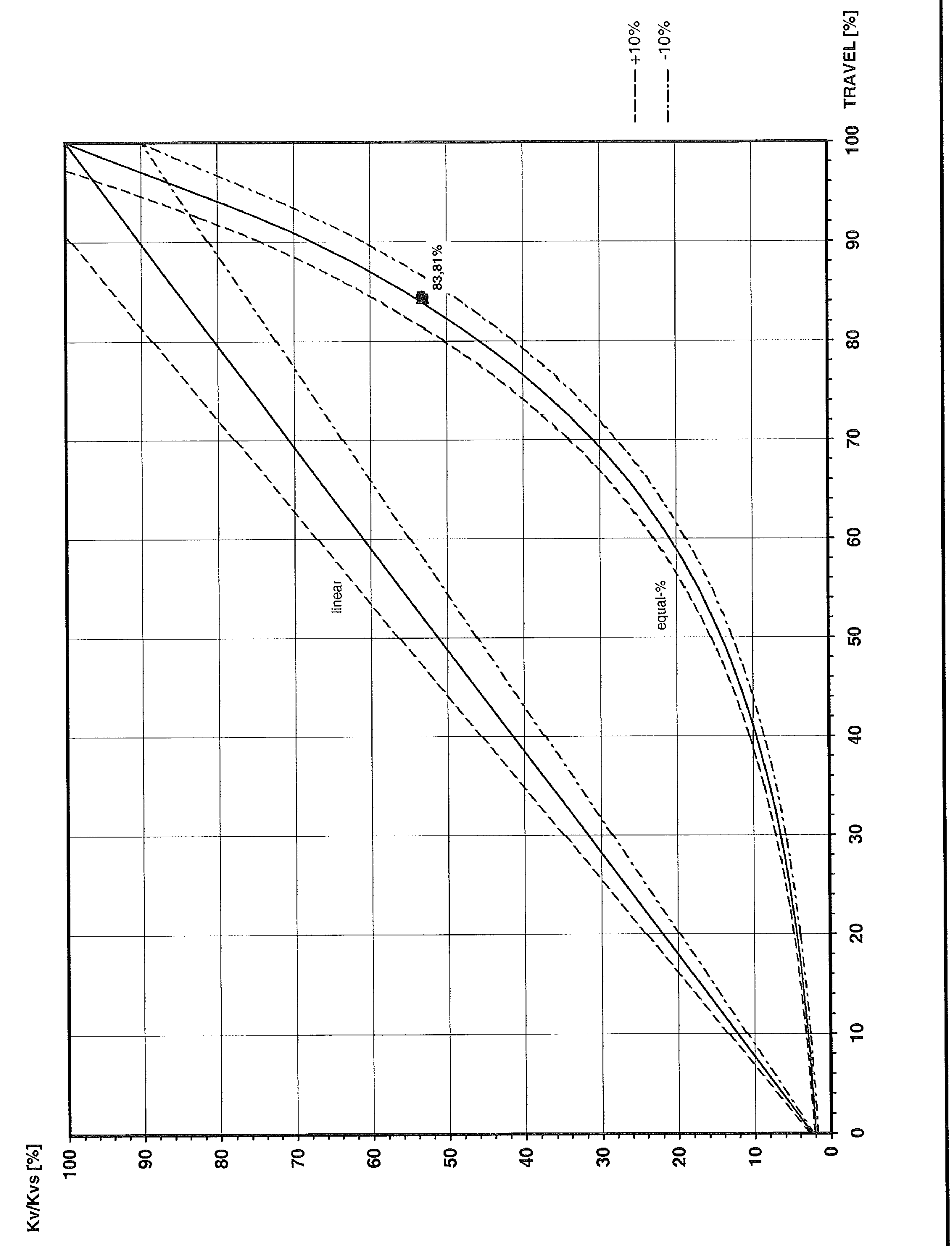
	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	10616,23	10616,23	10616,23
travel (%) (first give Kvs-value!)	83,81	83,81	83,81
selected Kvs-value	**Kvs=**	**20000,00**	
valve type	butterfly valve		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES		
gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	Specification Control Valve Characteristic	TAG - No.: **UK15014**
		Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15016** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	14872,37	18828,58	19197,78
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	72579,00	96400,00	96954,00
charge pressure (abs.)	**p1 [bar]**	5,36	5,62	5,54
discharge pressure (abs.)	**p2 [bar]**	5,36	5,62	5,54
pressure loss	**Δp [bar]**	0,005	0,00	0,00
mass flow	**G [kg/h]**	93844,65	124645,20	125361,52
medium density	**ρ1 [kg/m³]**	6,31	6,62	6,53
absolute temp. (inlet side)	**T1 [K]**	296,10	296,10	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,16	0,15	0,15
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,32	0,30	0,31

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	16885,02	21901,43	22185,91
travel (%) (first give Kvs-value!)	85,31	91,96	92,29
selected Kvs-value	**Kvs=**	**30000,00**	
valve type	butterfly valve		

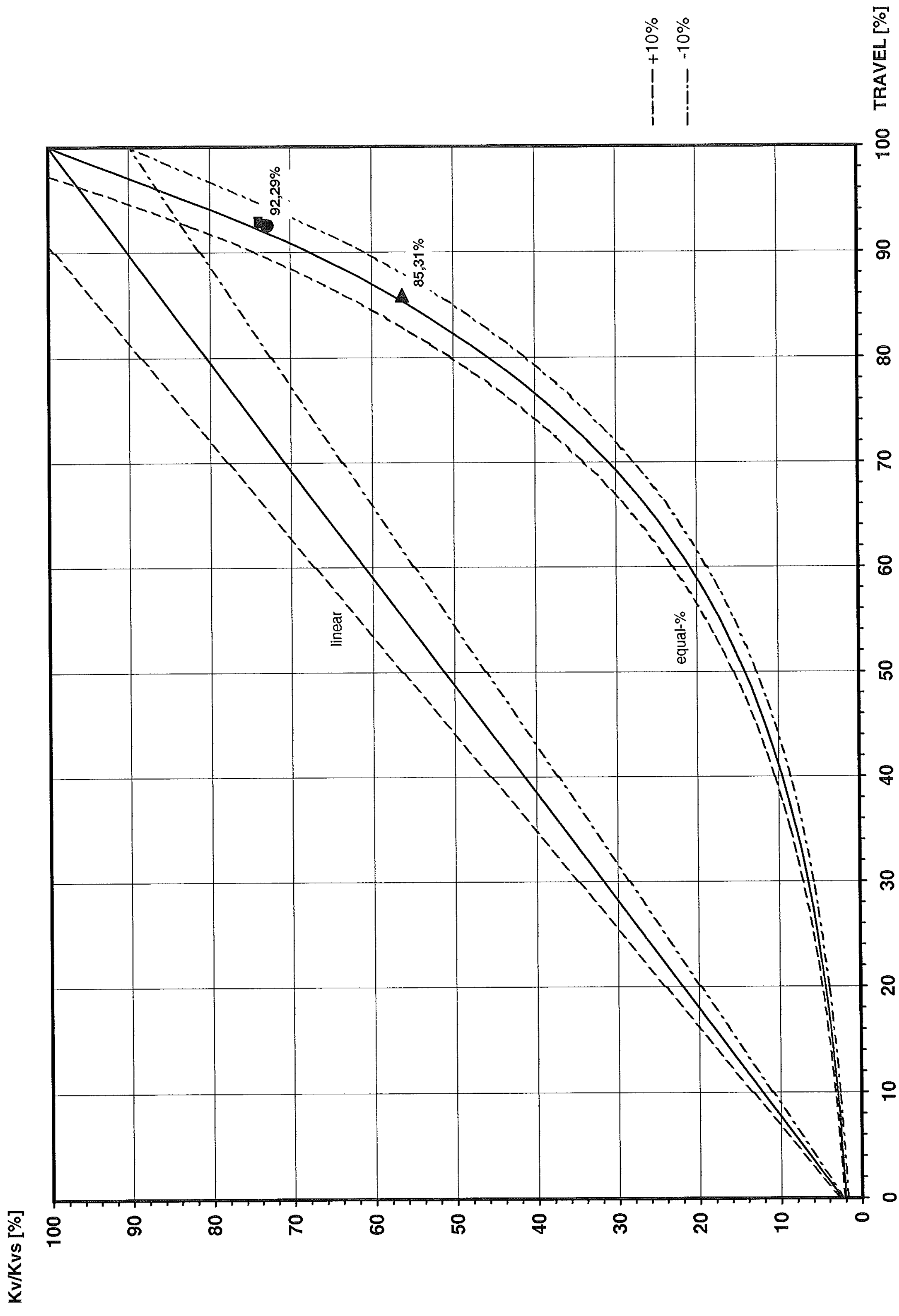
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15016** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15017** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	1077,50	1077,50	548,55
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	5500,00	5500,00	2800,00
charge pressure (abs.)	**p1 [bar]**	5,87	5,87	5,87
discharge pressure (abs.)	**p2 [bar]**	1,01	5,67	5,82
pressure loss	**Δp [bar]**	4,857	0,20	0,05
mass flow	**G [kg/h]**	7111,50	7111,50	3620,40
medium density	**ρ1 [kg/m³]**	6,60	6,60	6,60
absolute temp. (inlet side)	**T1 [K]**	288,00	288,00	288,00
spec. volume at p2 and t1	**V2 [m³/kg]**	0,82	0,15	0,14
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,28	0,28	0,28

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	70,35	193,90	194,87
travel (%) (first give Kvs-value!)	66,20	92,11	92,24
selected Kvs-value	**Kvs=**	**264,00**	
valve type	butterfly valve		

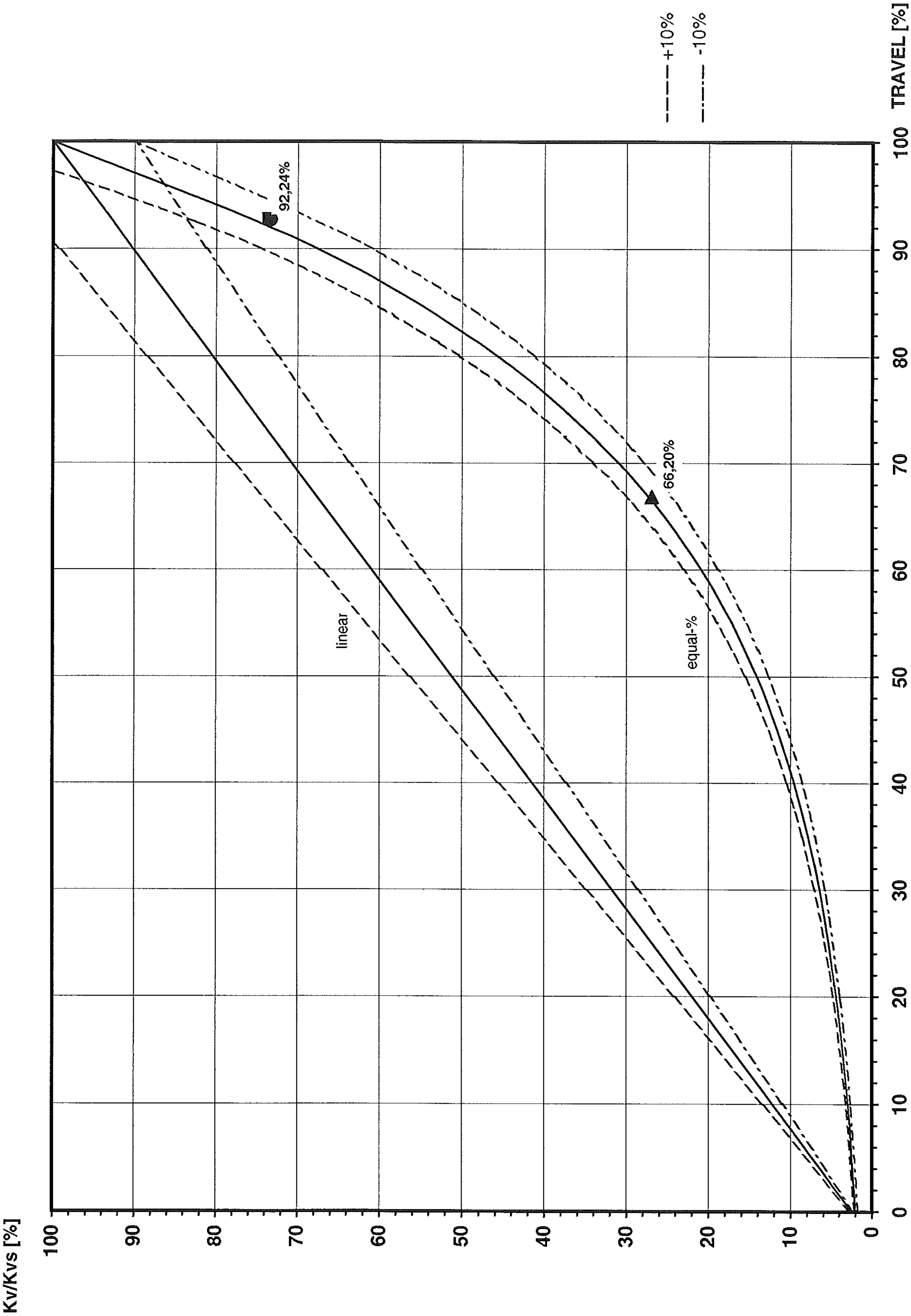
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15017** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15018** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
volume flow	Q [m³/h]	1077,50	1077,50	548,55
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	5500,00	5500,00	2800,00
charge pressure (abs.)	p1 [bar]	5,87	5,87	5,87
discharge pressure (abs.)	p2 [bar]	1,01	5,67	5,82
pressure loss	Δp [bar]	4,857	0,20	0,05
mass flow	G [kg/h]	7111,50	7111,50	3620,40
medium density	ρ1 [kg/m³]	6,60	6,60	6,60
absolute temp. (inlet side)	T1 [K]	288,00	288,00	288,00
spec. volume at p2 and t1	V2 [m³/kg]	0,82	0,15	0,14
spec. volume at p1/2 and t1	V* [m³/kg]	0,28	0,28	0,28

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	70,35	193,90	194,87
travel (%) (first give Kvs-value!)	66,20	92,11	92,24
selected Kvs-value	**Kvs=**	**264,00**	
valve type	butterfly valve		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

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0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15018** Project No.: K70101
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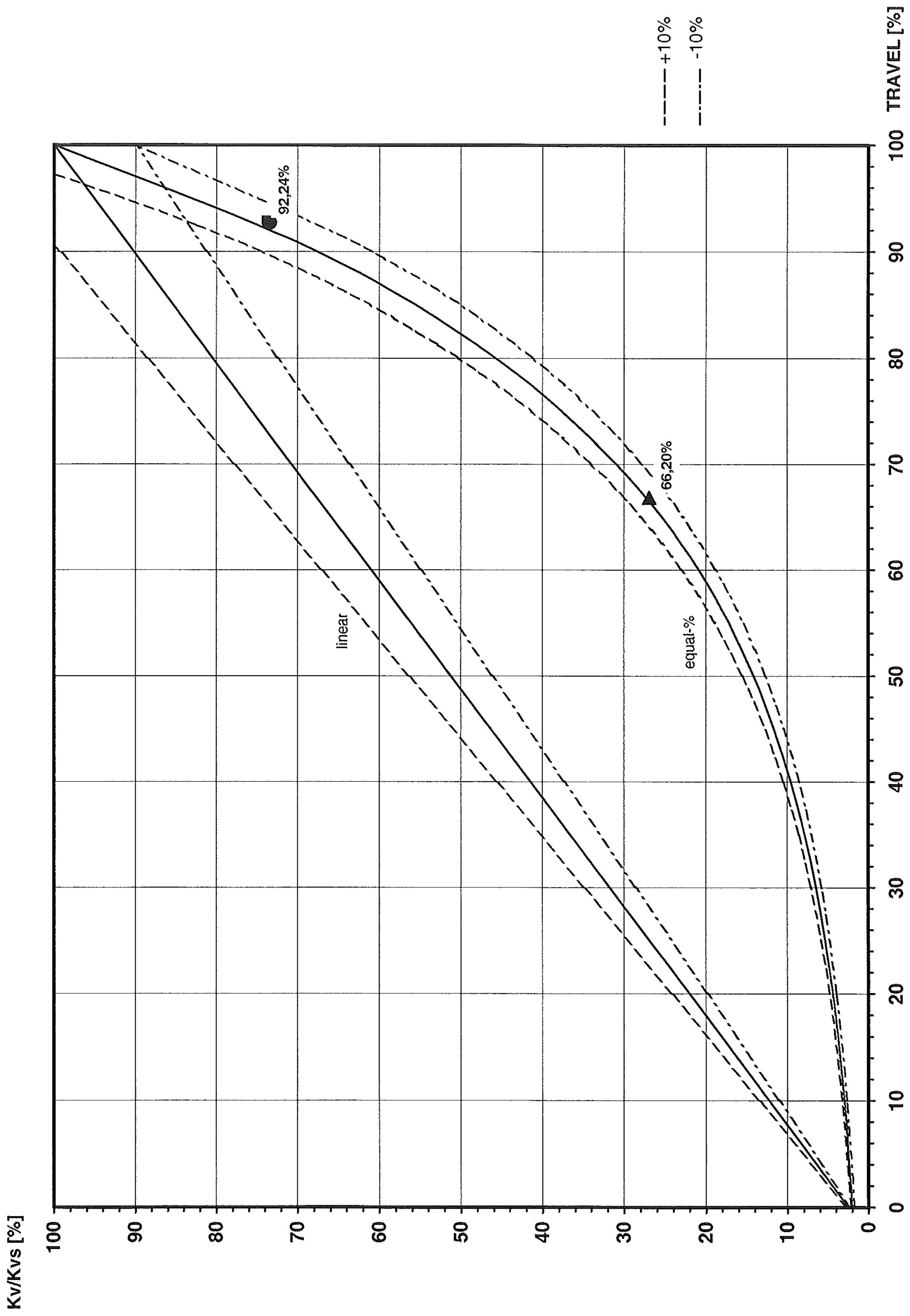

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

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AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

Project: **ASU No. 9 KOSICE**

TAG - No.: **UK15021**

Project-No.: K70101

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calculation of Kv-value	pressure gradient	liquids flow (m^3/h)	liquids flow (kg/h)	gases flow (m^3/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^*\Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{257 p1}\sqrt{\rho_N{}^*T1}$	$K_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

	medium	air		
	state	gaseous		
	standard density	1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	14111,98	17630,16	18068,83
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	72579,00	96400,00	96954,00
charge pressure (abs.)	**p1 [bar]**	5,50	5,82	5,72
discharge pressure (abs.)	**p2 [bar]**	5,50	5,82	5,72
pressure loss	**Δp [bar]**	0,005	0,00	0,00
mass flow	**G [kg/h]**	93844,65	124645,20	125361,52
medium density	**ρ1 [kg/m³]**	6,65	7,07	6,94
absolute temp. (inlet side)	**T1 [K]**	288,60	287,00	287,70
spec. volume at p2 and t1	**V2 [m³/kg]**	0,15	0,14	0,14
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,30	0,28	0,29

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	16456,08	21188,21	21521,80
travel (%) (first give Kvs-value!)	84,65	91,11	91,51
selected Kvs-value	**Kvs=**	**30000,00**	
valve type	butterfly valve		

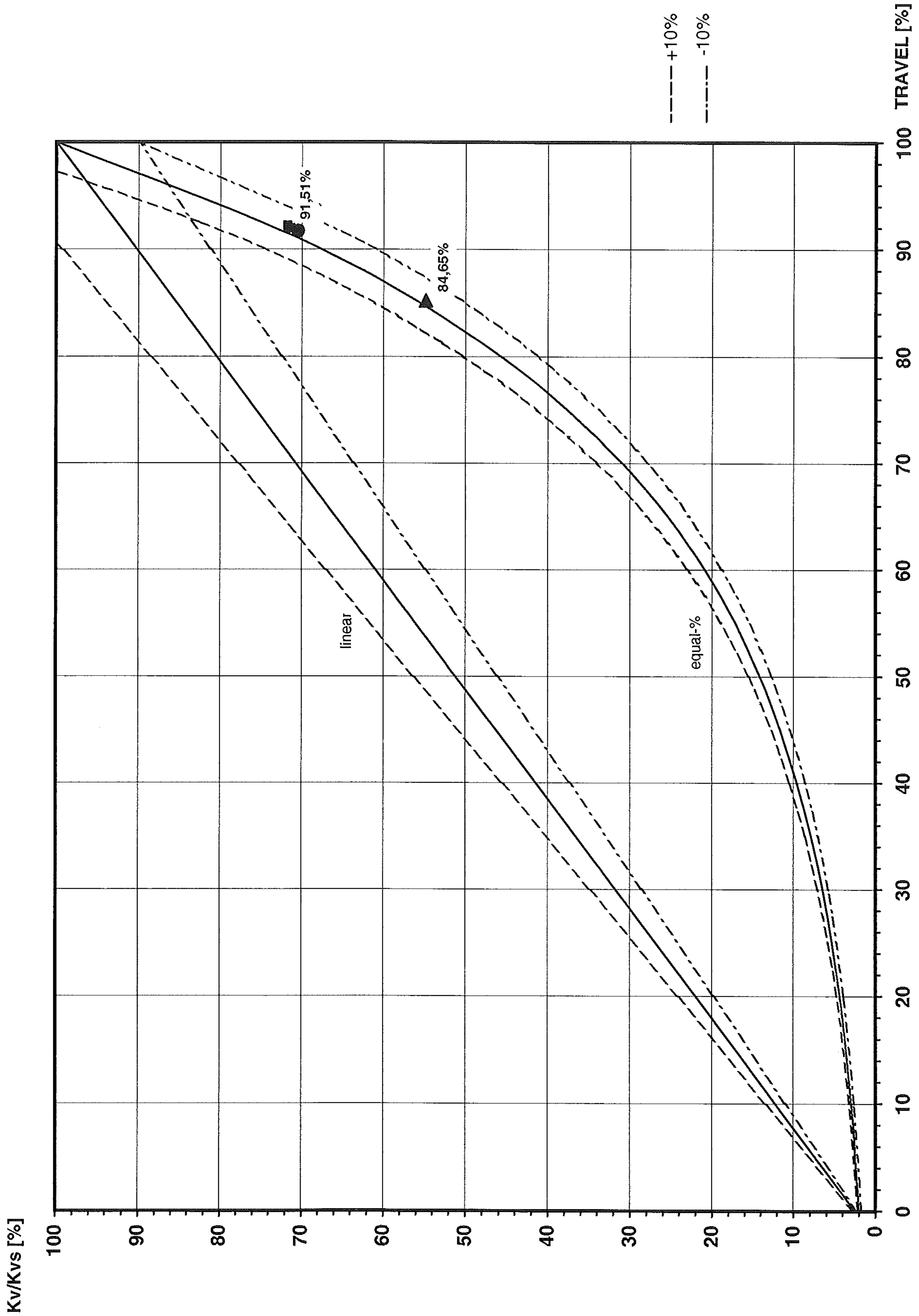
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15021** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15022** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
	medium	nitrogen		
	state	gaseous		
	standard density	1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	24411,28	24411,28	24411,28
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	18000,00	18000,00	18000,00
charge pressure (abs.)	**p1 [bar]**	1,02	1,02	1,02
discharge pressure (abs.)	**p2 [bar]**	1,02	1,02	1,02
pressure loss	**Δp [bar]**	0,005	0,01	0,01
mass flow	**G [kg/h]**	22507,20	22507,20	22507,20
medium density	**ρ1 [kg/m³]**	0,92	0,92	0,92
absolute temp. (inlet side)	**T1 [K]**	373,00	373,00	373,00
spec. volume at p2 and t1	**V2 [m³/kg]**	1,09	1,09	1,09
spec. volume at p1/2 and t1	**V* [m³/kg]**	2,17	2,17	2,17

	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	10616,23	10616,23	10616,23
travel (%) (first give Kvs-value!)	83,81	83,81	83,81
selected Kvs-value	**Kvs=**	**20000,00**	
valve type	butterfly valve		

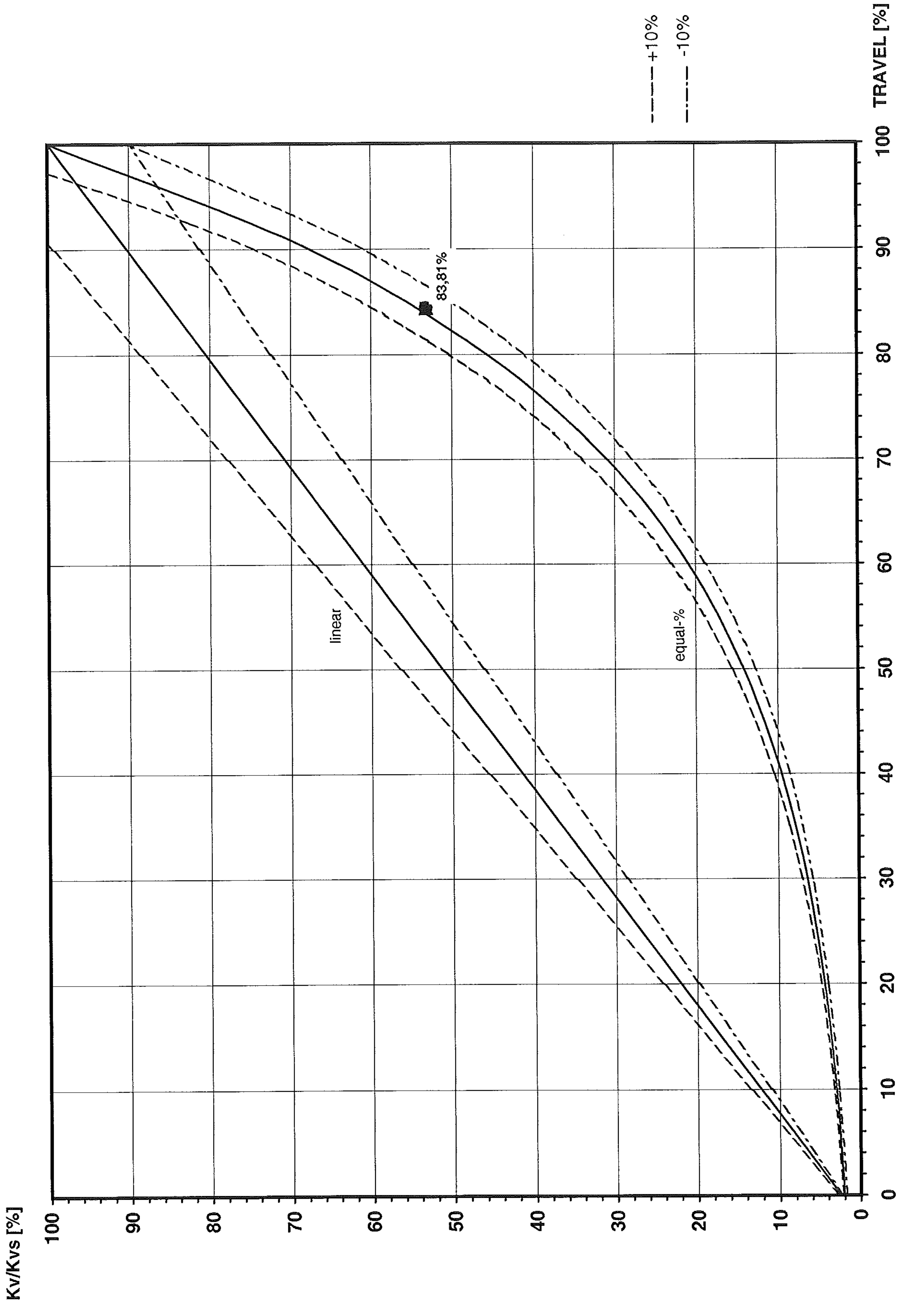
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15022** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

UK15022_calc.XLS SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15023** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
volume flow	Q [m³/h]	1077,50	1077,50	225,30
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	5500,00	5500,00	1150,00
charge pressure (abs.)	p1 [bar]	5,87	3,10	1,06
discharge pressure (abs.)	p2 [bar]	1,01	1,01	1,01
pressure loss	Δp [bar]	4,857	2,09	0,05
mass flow	G [kg/h]	7111,50	7111,50	1486,95
medium density	ρ1 [kg/m³]	6,60	6,60	6,60
absolute temp. (inlet side)	T1 [K]	288,00	288,00	288,00
spec. volume at p2 and t1	V2 [m³/kg]	0,82	0,82	0,82
spec. volume at p1/2 and t1	V* [m³/kg]	0,28	0,53	1,56

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	70,35	133,22	197,87
travel (%) (first give Kvs-value!)	66,20	82,52	92,63
selected Kvs-value	Kvs=	264,00	
valve type	butterfly valve		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

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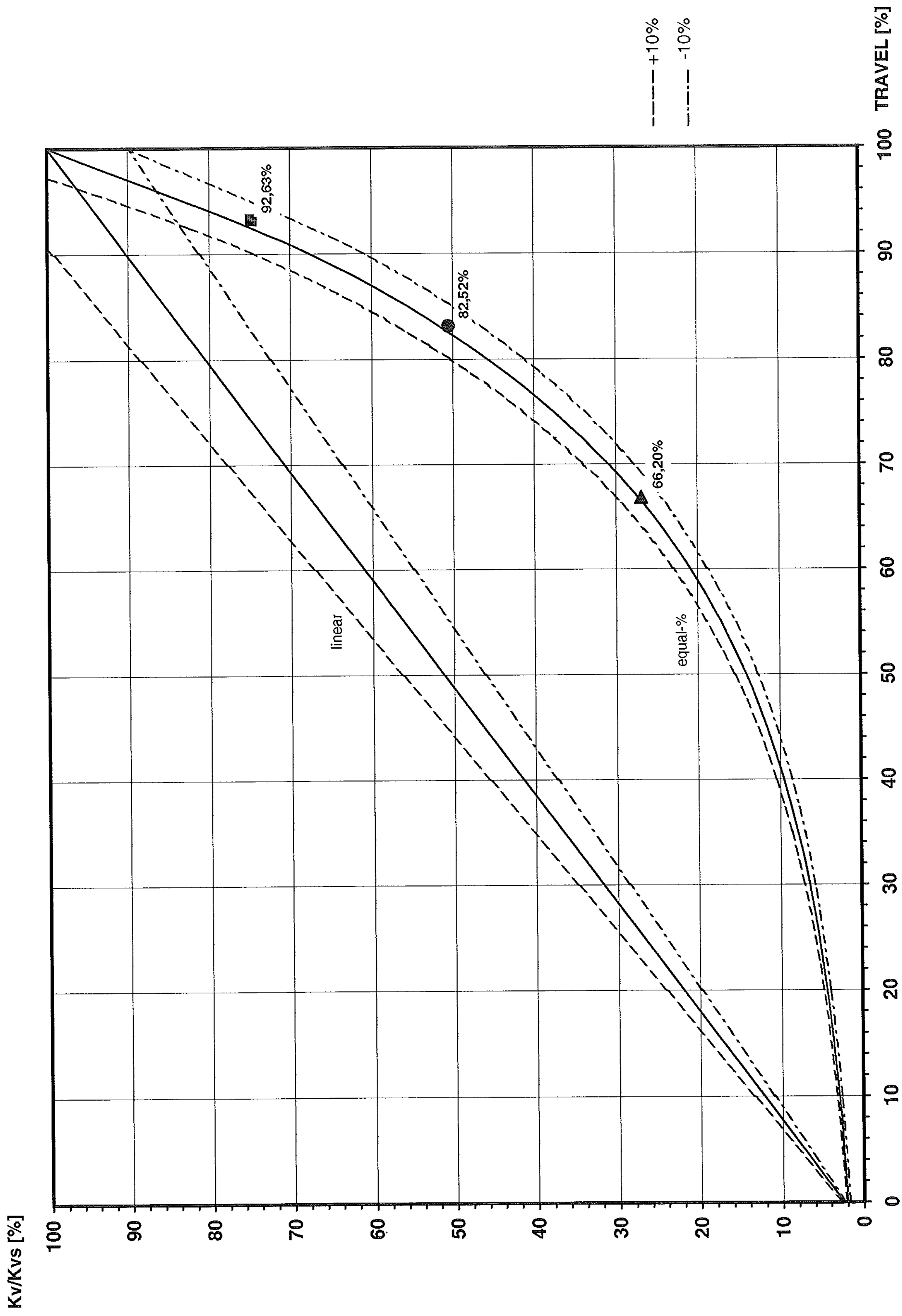
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15023**
		Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



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Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

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SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

Project: **ASU No. 9 KOSICE**

TAG - No.: **UK15024**

Project-No.: K70101

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	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
volume flow	Q [m³/h]	22643,06	22643,06	22643,06
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	18000,00	18000,00	18000,00
charge pressure (abs.)	p1 [bar]	1,12	1,12	1,12
discharge pressure (abs.)	p2 [bar]	1,12	1,12	1,12
pressure loss	Δp [bar]	0,005	0,01	0,01
mass flow	G [kg/h]	22507,20	22507,20	22507,20
medium density	$\rho 1$ [kg/m³]	0,99	0,99	0,99
absolute temp. (inlet side)	T1 [K]	473,00	473,00	473,00
spec. volume at p2 and t1	V2 [m³/kg]	1,26	1,26	1,26
spec. volume at p1/2 and t1	V* [m³/kg]	2,51	2,51	2,51

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	11406,23	11406,23	11406,23
travel (%) (first give Kvs-value!)	85,64	85,64	85,64
selected Kvs-value	Kvs= **20000,00**		
valve type	butterfly valve		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

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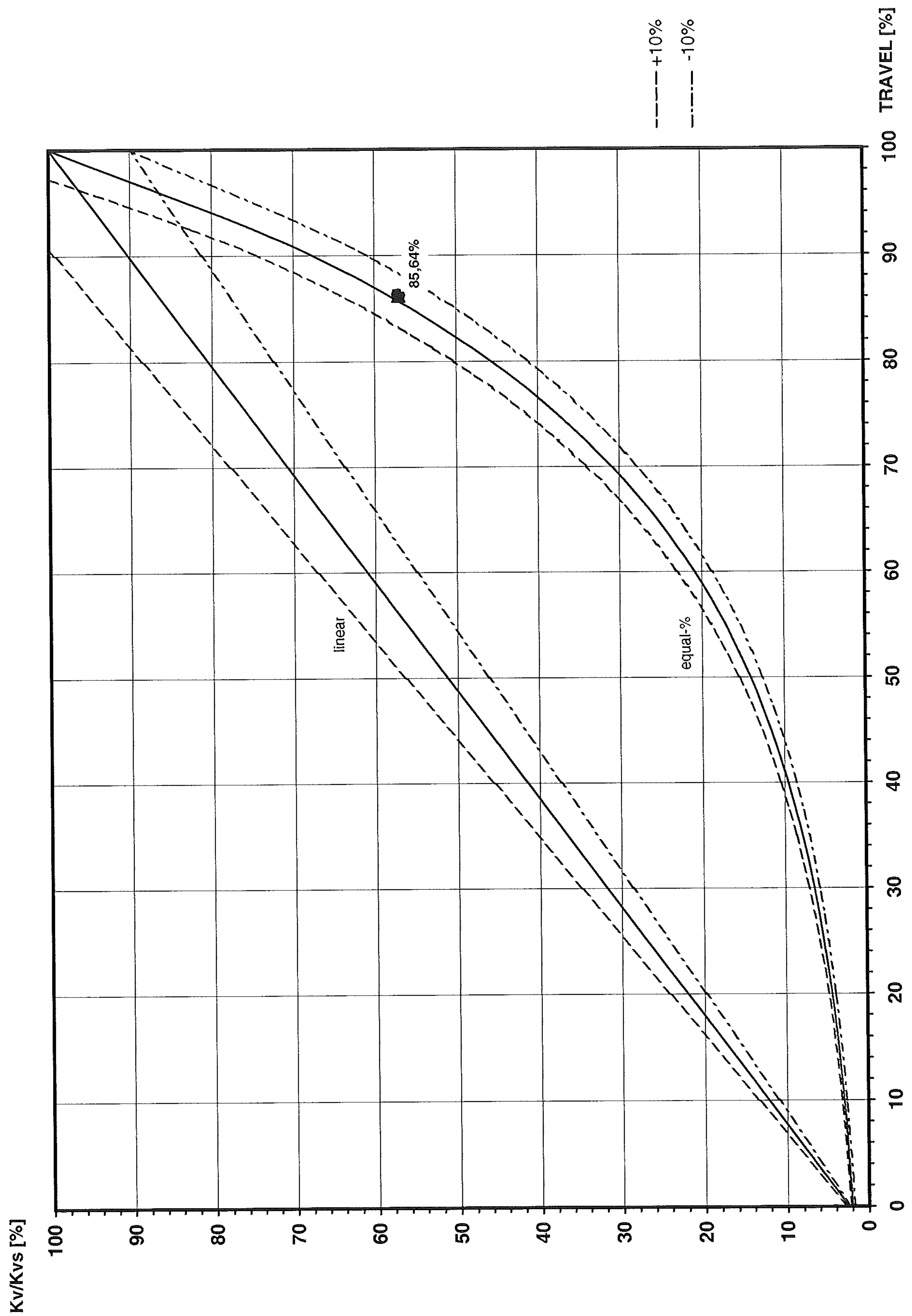
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15024** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15026** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m^3/h)	liquids flow (kg/h)	gases flow (m^3/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
volume flow	**Q [m³/h]**	14872,37	18828,58	19197,78
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	72579,00	96400,00	96954,00
charge pressure (abs.)	**p1 [bar]**	5,36	5,62	5,54
discharge pressure (abs.)	**p2 [bar]**	5,36	5,62	5,54
pressure loss	**Δp [bar]**	0,005	0,00	0,00
mass flow	**G [kg/h]**	93844,65	124645,20	125361,52
medium density	**ρ1 [kg/m³]**	6,31	6,62	6,53
absolute temp. (inlet side)	**T1 [K]**	296,10	296,10	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,16	0,15	0,15
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,32	0,30	0,31

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	16885,02	21901,43	22185,91
travel (%) (first give Kvs-value!)	85,31	91,96	92,29
selected Kvs-value	**Kvs=**	**30000,00**	
valve type	**butterfly valve**		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

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AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15026** Project No.: K70101
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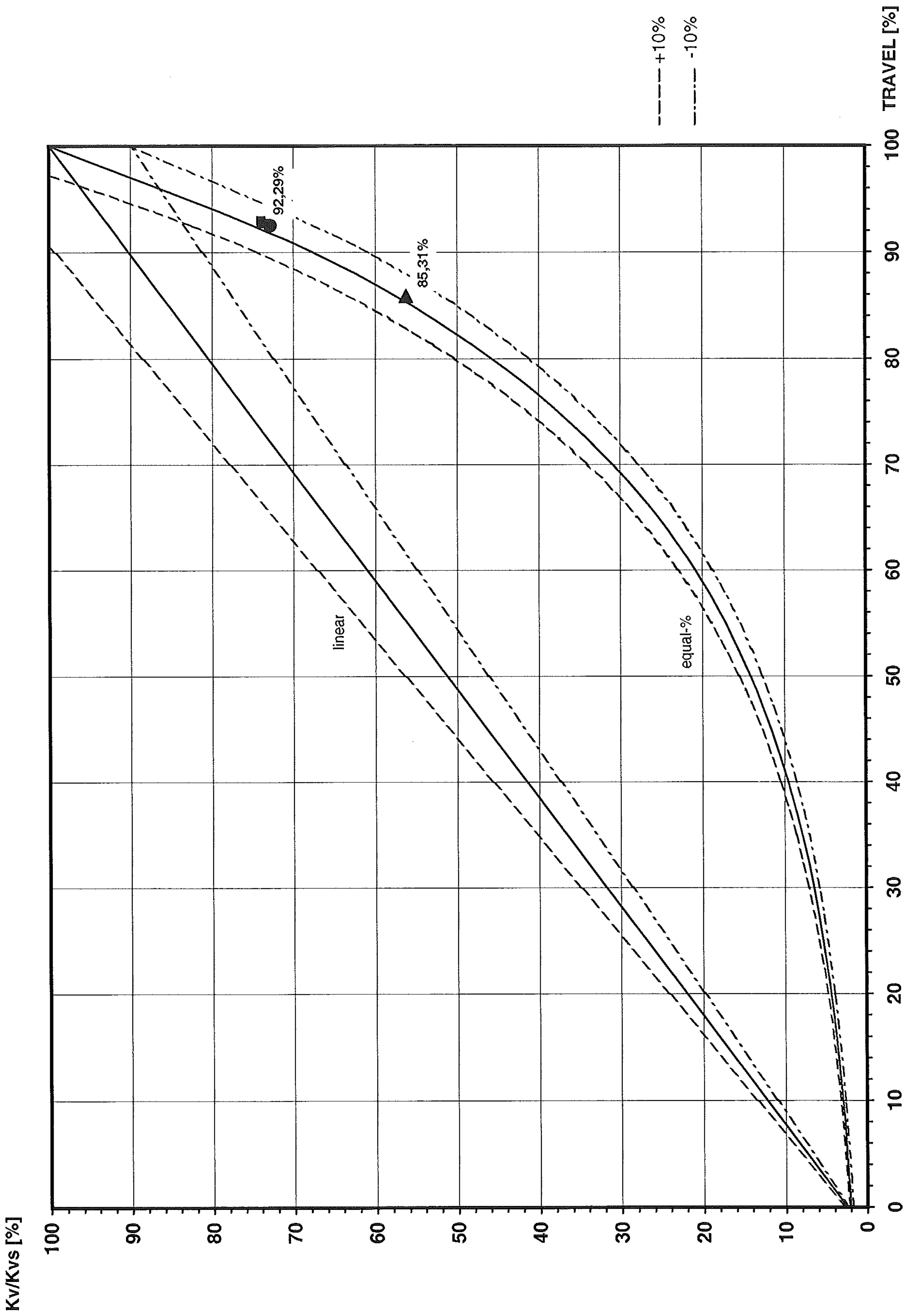

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15028** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	1077,50	1077,50	548,55
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	5500,00	5500,00	2800,00
charge pressure (abs.)	**p1 [bar]**	5,87	5,87	5,87
discharge pressure (abs.)	**p2 [bar]**	1,01	5,67	5,82
pressure loss	**Δp [bar]**	4,857	0,20	0,05
mass flow	**G [kg/h]**	7111,50	7111,50	3620,40
medium density	**ρ1 [kg/m³]**	6,60	6,60	6,60
absolute temp. (inlet side)	**T1 [K]**	288,00	288,00	288,00
spec. volume at p2 and t1	**V2 [m³/kg]**	0,82	0,15	0,14
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,28	0,28	0,28
		RESULTS		
		case 1	**case 2**	**case 3**
pressure gradient		supercritical	subcritical	subcritical
flash (%)				
Kv_flash				
Kv_liquid				
Kv_tot		70,35	193,90	194,87
travel (%) (first give Kvs-value!)		66,20	92,11	92,24
selected Kvs-value		**Kvs=**	**264,00**	
valve type		**butterfly valve**		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

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AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15028** Project No.: K70101
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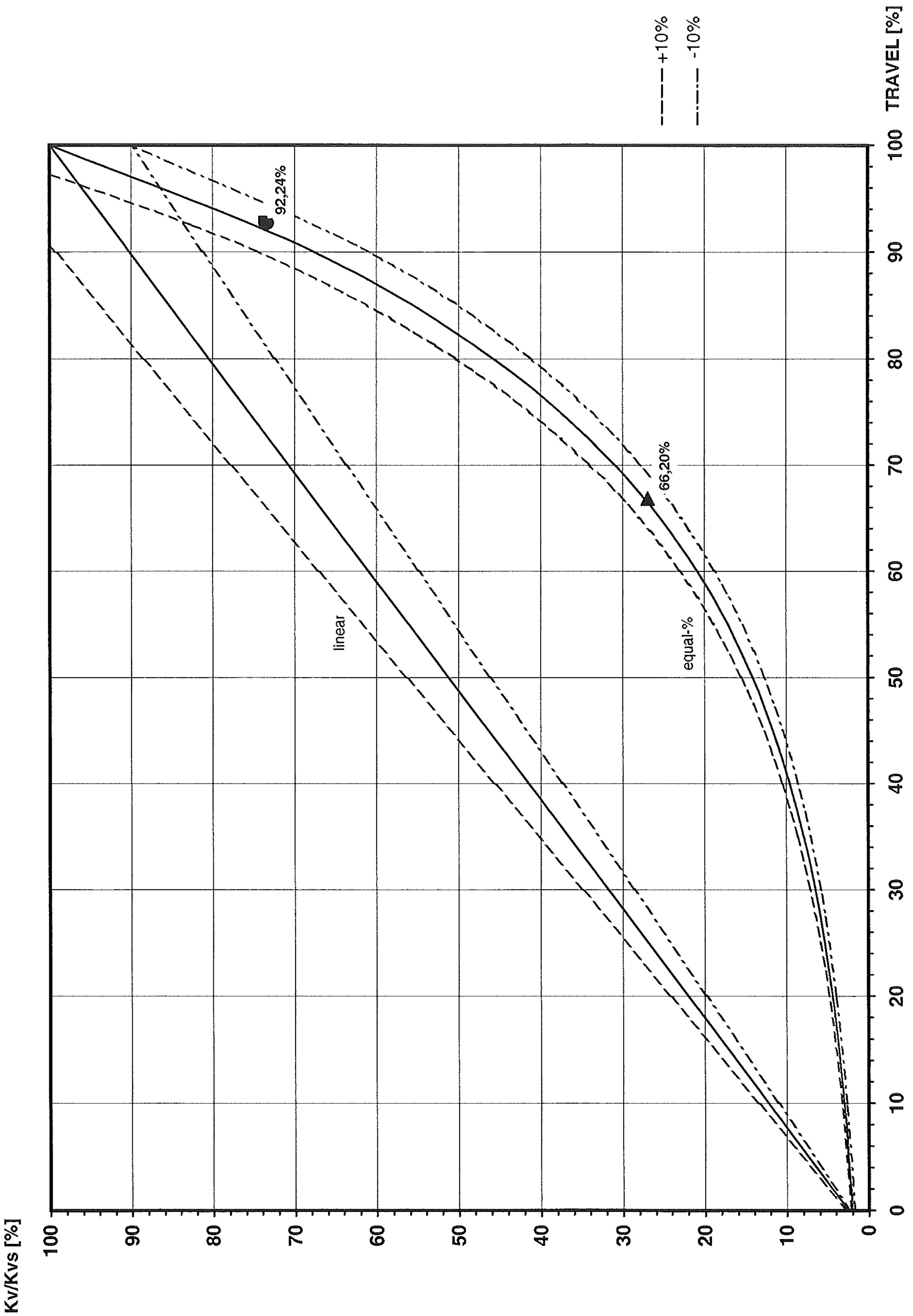

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AIR LIQUIDE	# Specification Calculation of Control (Butterfly-)Valves	TAG - No.: **PV15037**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids: flow (m³/h)	liquids: flow (kg/h)	gases: flow (m³/h)	gases: flow (kg/h)	steam: flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
volume flow	**Q [m³/h]**	3720,86	3424,16	3365,73
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	18000,00	18000,00	18000,00
charge pressure (abs.)	**p1 [bar]**	5,310	5,77	5,87
discharge pressure (abs.)	**p2 [bar]**	1,250	1,17	1,17
pressure loss	**Δp [bar]**	4,060	4,60	4,70
mass flow	**G [kg/h]**	23274,00	23274,00	23274,00
medium density	**ρ1 [kg/m³]**	6,255	6,80	6,92
absolute temp. (inlet side)	**T1 [K]**	296,10	296,10	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,68	0,73	0,73
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,32	0,29	0,29

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	258,09	237,51	233,46
travel (%) (first give Kvs-value!)	85,79	83,66	83,23
selected Kvs-value	**Kvs=**	**450,00**	
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

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0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **PV15037** Project No.: K70101
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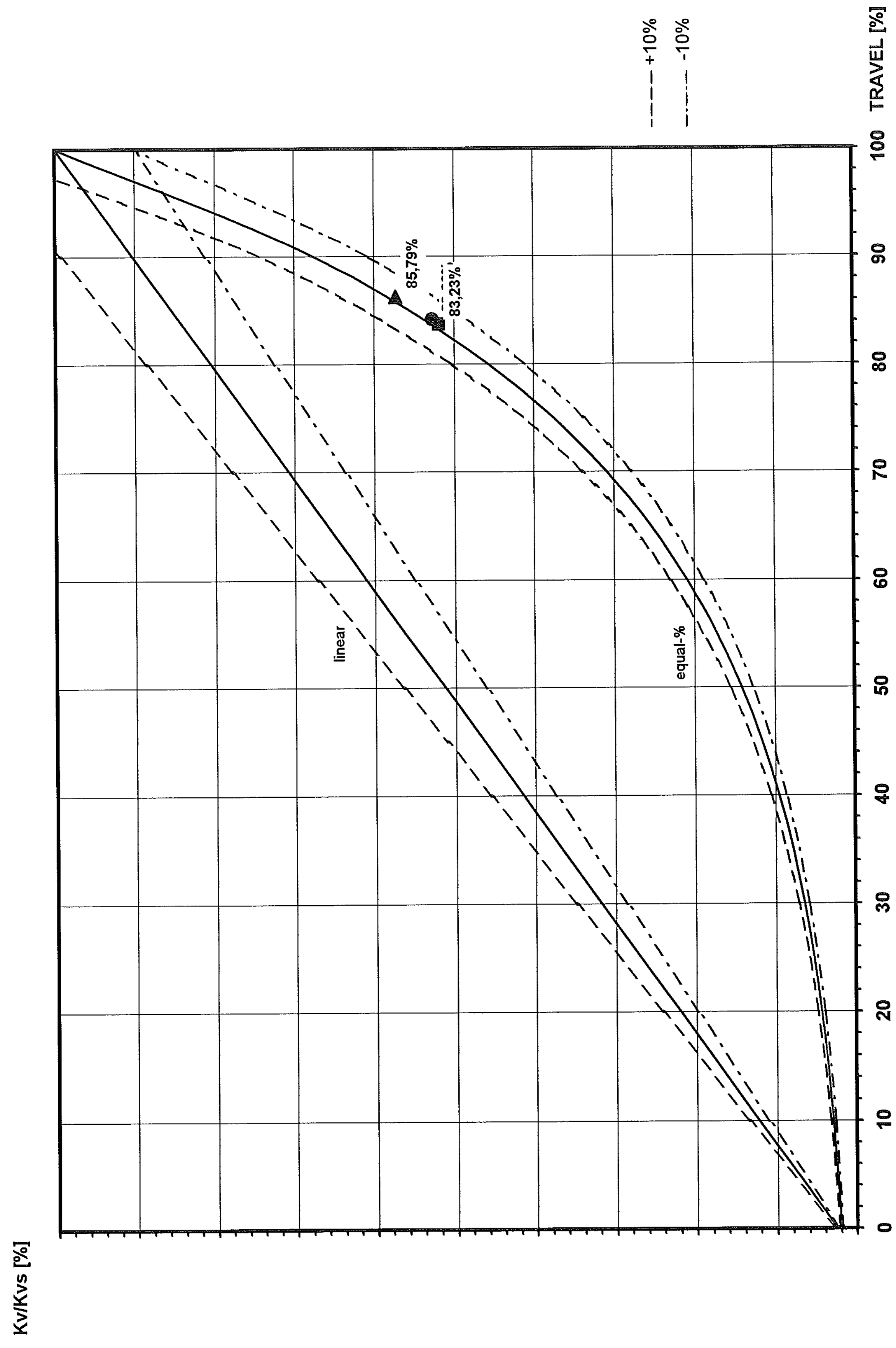

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Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **PK15041**
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Project-No.: K70101
		Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257p1} \sqrt{\rho_N{}^*T1}$	$k_v = \frac{G}{257p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	4041,63	19447,45	21557,56
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	4648,00	20841,00	23223,00
charge pressure (abs.)	**p1 [bar]**	1,25	1,17	1,17
discharge pressure (abs.)	**p2 [bar]**	1,07	1,07	1,07
pressure loss	**Δp [bar]**	0,180	0,10	0,10
mass flow	**G [kg/h]**	5811,86	26059,59	29038,04
medium density	**ρ1 [kg/m³]**	1,44	1,34	1,35
absolute temp. (inlet side)	**T1 [K]**	293,30	294,80	292,90
spec. volume at p2 and t1	**V2 [m³/kg]**	0,81	0,82	0,81
spec. volume at p1/2 and t1	**V* [m³/kg]**	1,39	1,50	1,49

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	394,60	2379,86	2643,31
travel (%) (first give Kvs-value!)	20,22	66,16	68,84
selected Kvs-value	**Kvs=**	**8944,00**	
valve type	**butterfly valve**		

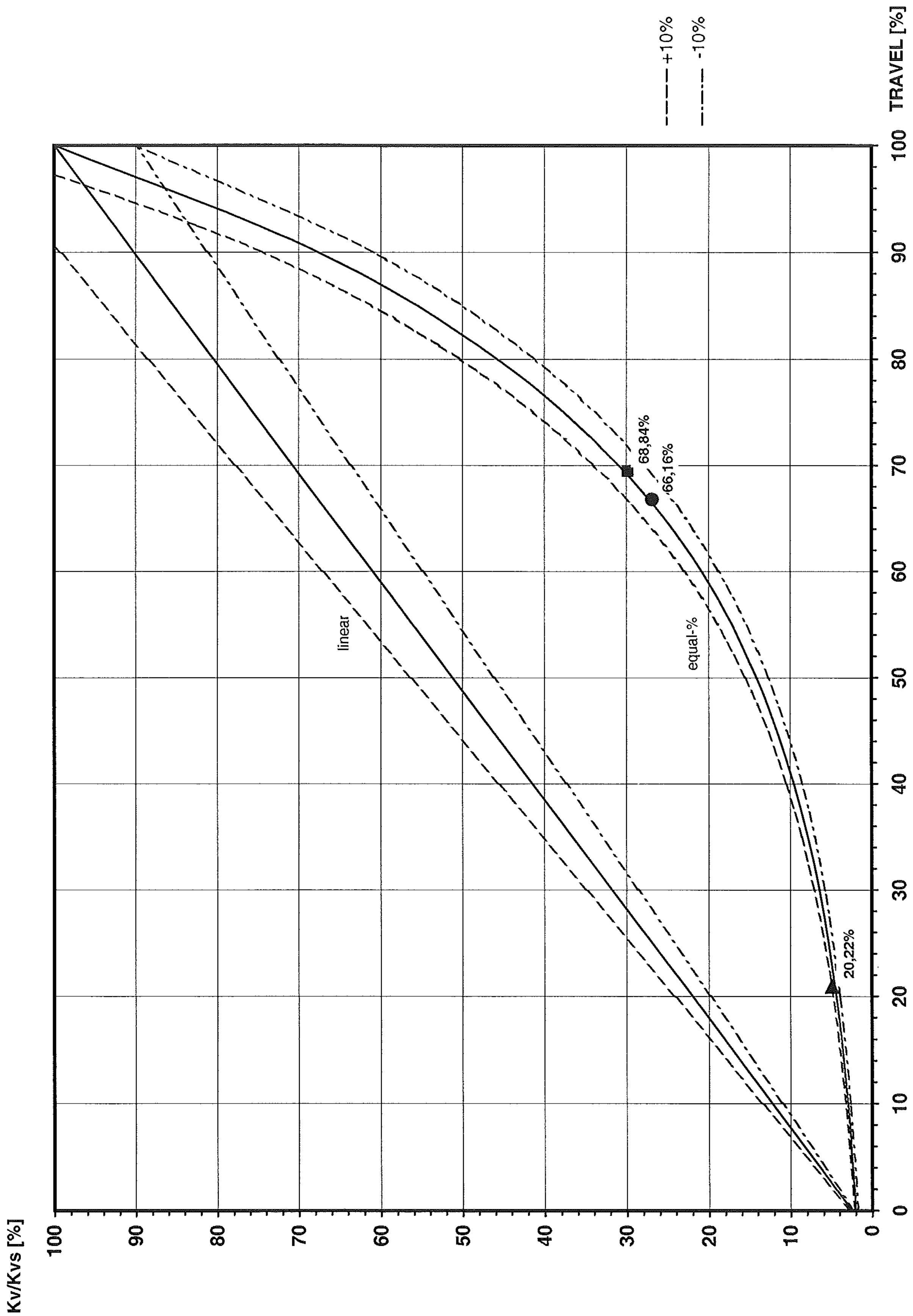
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **PK15041** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		water		
state		liquid		
standard density		1000,0000 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	1,96	1,96	1,96
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	1,90	1,90	1,90
charge pressure (abs.)	**p1 [bar]**	11,000	11,00	11,00
discharge pressure (abs.)	**p2 [bar]**	1,000	1,00	1,00
pressure loss	**Δp [bar]**	10,000	10,00	10,00
mass flow	**G [kg/h]**	1900,00	1900,00	1900,00
medium density	**$\rho 1$ [kg/m³]**	971,700	971,70	971,70
absolute temp. (inlet side)	**T1 [K]**	353,00	353,00	353,00
spec. volume at p2 and t1	**V2 [m³/kg]**	0,00	0,00	0,00
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,00	0,00	0,00

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	0,61	0,61	0,61
Kv_tot	0,61	0,61	0,61
travel (%) (first give Kvs-value!)	75,33	75,33	75,33
selected Kvs-value	**Kvs=**	**1,60**	
valve type	globe valve		

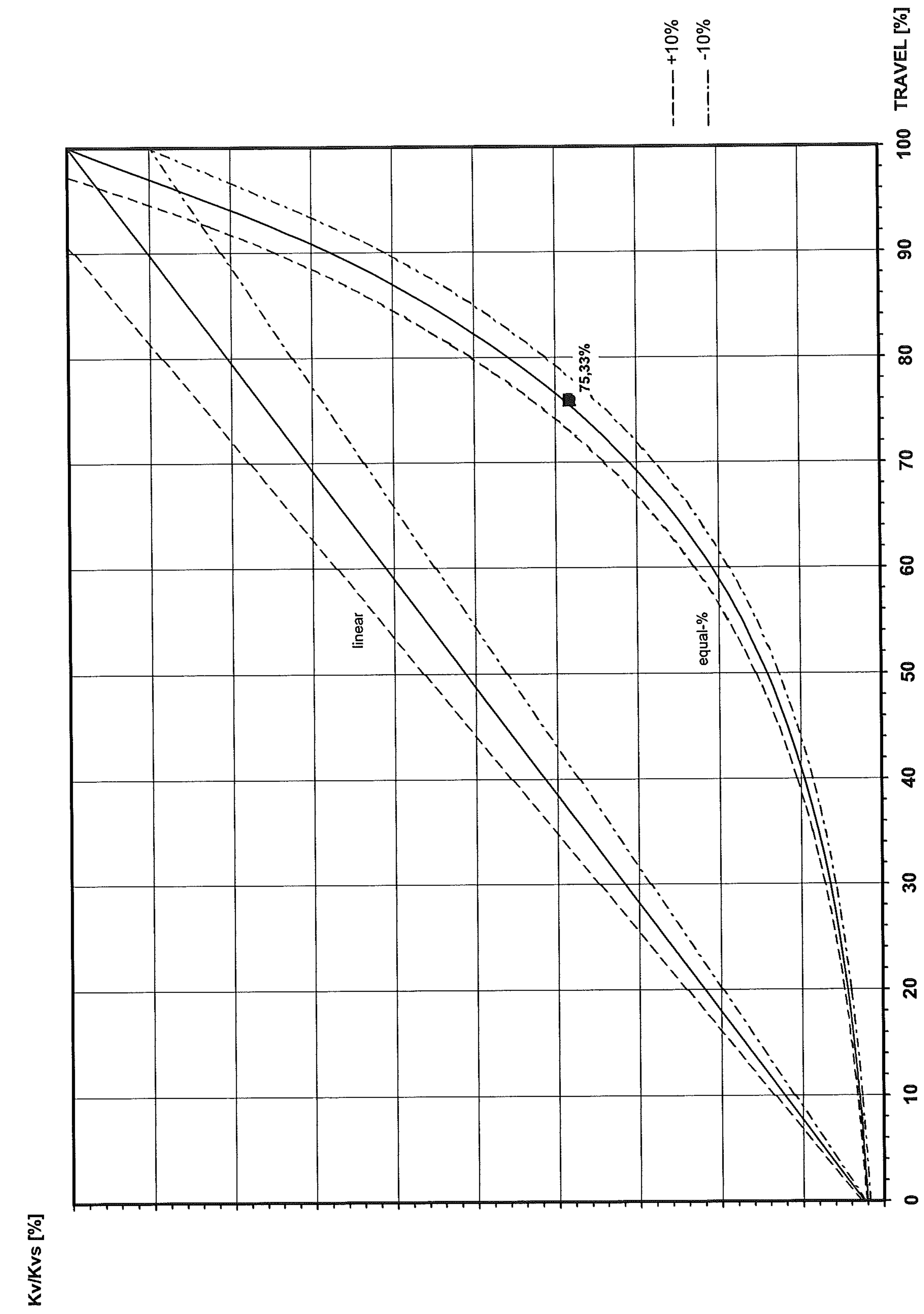
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.:	**TV15043**
		Project No.:	K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page:	of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

TV15043_calc

SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

Project: **ASU No. 9 KOSICE**

TAG - No.: **UK15044**

Project-No.: K70101

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calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000 * \Delta p}}$	$k_v = \frac{G}{\sqrt{1000 * \rho 1 * \Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N * T1}{\Delta p * p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N * \Delta p * p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1}\sqrt{\rho_N * T1}$	$k_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	Q [m³/h]	15805,62	16709,13	16635,03
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	18000,00	18000,00	18000,00
charge pressure (abs.)	p1 [bar]	1,25	1,17	1,17
discharge pressure (abs.)	p2 [bar]	1,12	1,12	1,12
pressure loss	Δp [bar]	0,130	0,05	0,05
mass flow	G [kg/h]	22507,20	22507,20	22507,20
medium density	ρ1 [kg/m³]	1,42	1,35	1,35
absolute temp. (inlet side)	T1 [K]	296,10	292,90	292,30
spec. volume at p2 and t1	V2 [m³/kg]	0,78	0,78	0,77
spec. volume at p1/2 and t1	V* [m³/kg]	1,41	1,49	1,48

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	1765,93	2832,04	2829,14
travel (%) (first give Kvs-value!)	58,53	70,60	70,58
selected Kvs-value	**Kvs=**	**8944,00**	
valve type	**butterfly valve**		

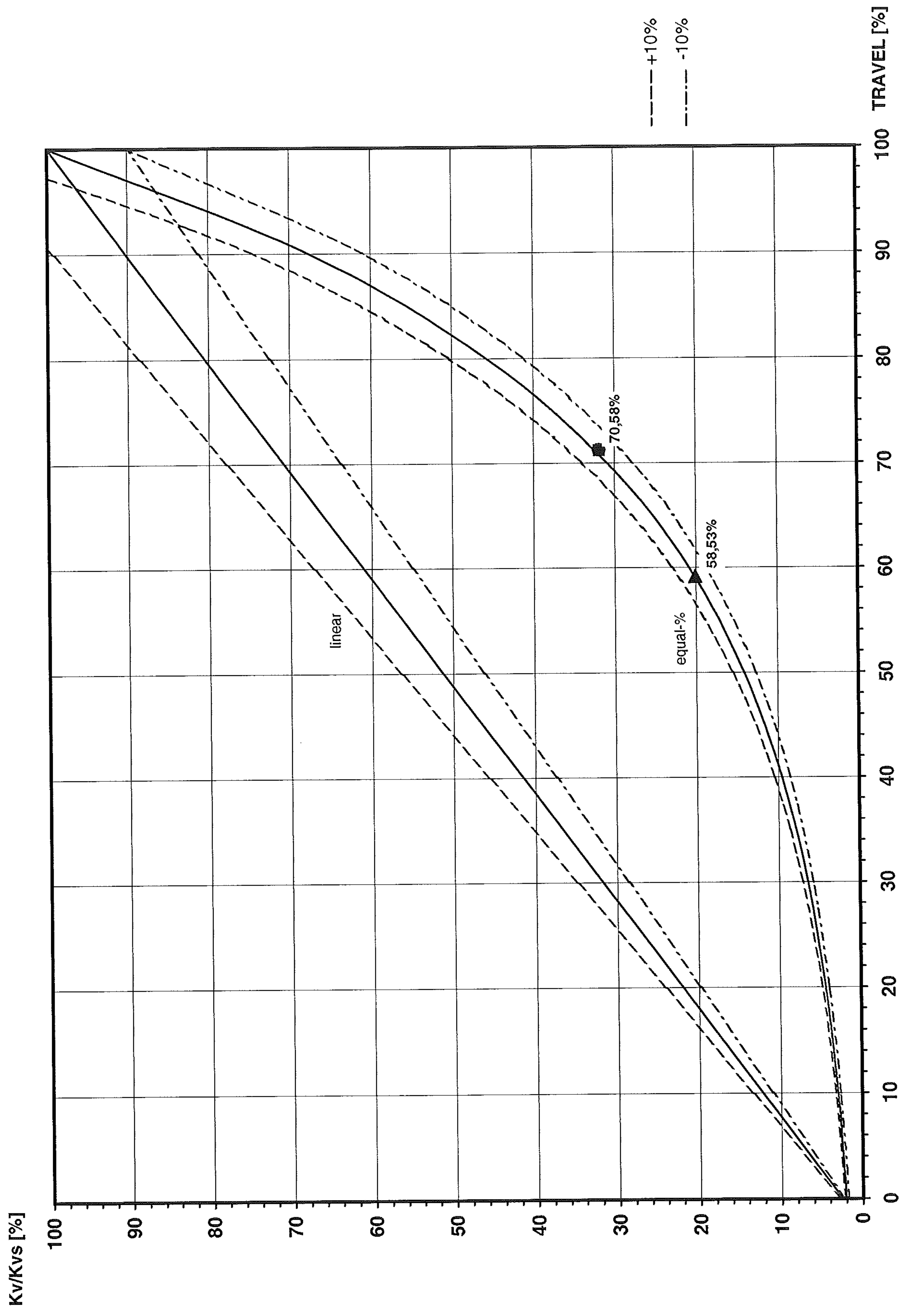
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15044** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK15045** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	15805,62	16709,13	16635,03
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	18000,00	18000,00	18000,00
charge pressure (abs.)	**p1 [bar]**	1,25	1,17	1,17
discharge pressure (abs.)	**p2 [bar]**	1,12	1,12	1,12
pressure loss	**Δp [bar]**	0,130	0,05	0,05
mass flow	**G [kg/h]**	22507,20	22507,20	22507,20
medium density	**ρ1 [kg/m³]**	1,42	1,35	1,35
absolute temp. (inlet side)	**T1 [K]**	296,10	292,90	292,30
spec. volume at p2 and t1	**V2 [m³/kg]**	0,78	0,78	0,77
spec. volume at p1/2 and t1	**V* [m³/kg]**	1,41	1,49	1,48

	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	1765,93	2832,04	2829,14
travel (%) (first give Kvs-value!)	58,53	70,60	70,58
selected Kvs-value	**Kvs=**	**8944,00**	
valve type	**butterfly valve**		

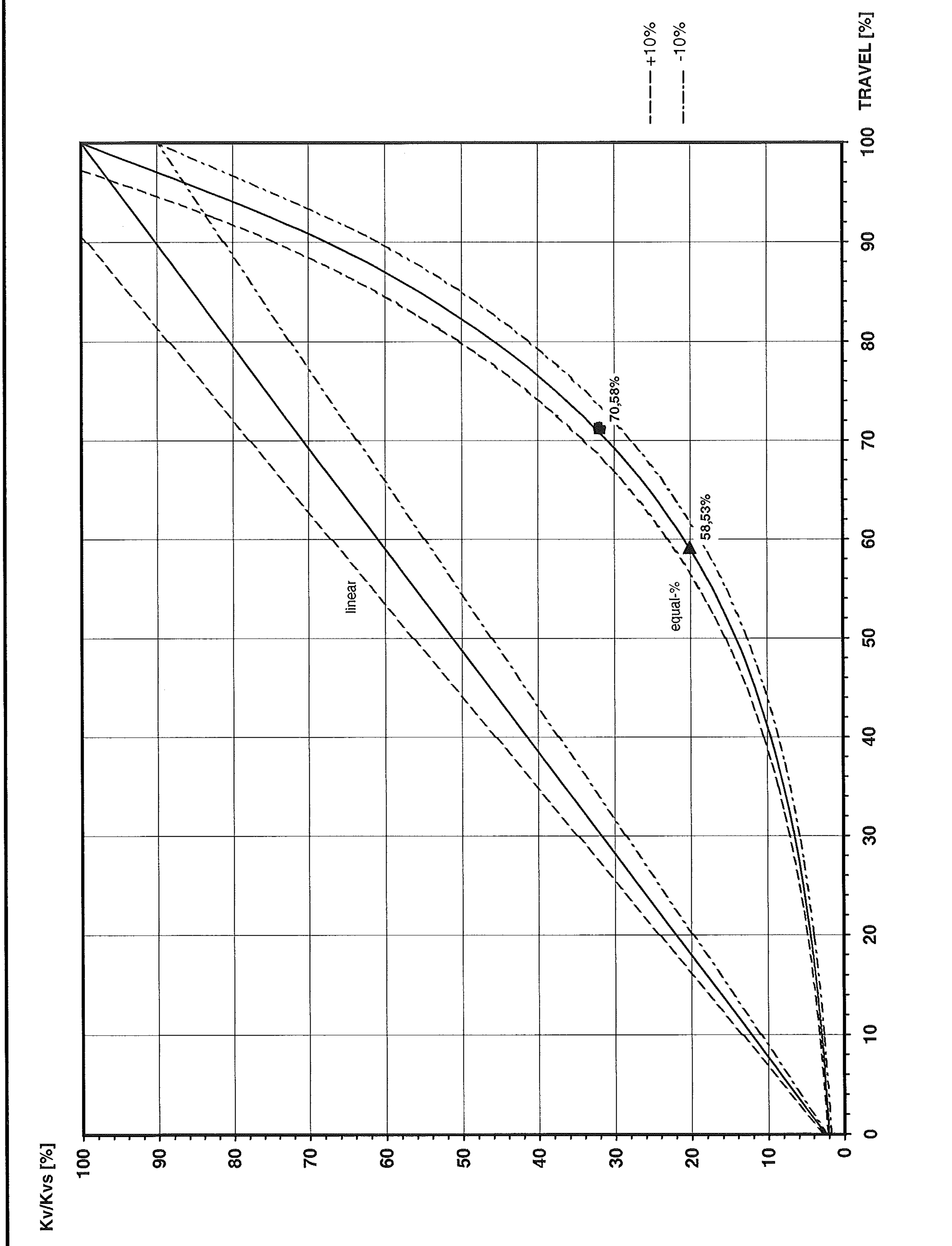
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK15045** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE Air Liquide AGS GmbH	**Specification** Calculation of Control (Butterfly-)Valves Project: **ASU No. 9 KOSICE**	TAG - No.: **PK16007** Project-No.: K70101 Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^*\sqrt{\frac{\rho 1}{1000*\Delta p}}$	$k_v = \frac{G}{\sqrt{1000*\rho 1*\Delta p}}$	$k_v=\frac{Q_N}{514}\sqrt{\frac{\rho_N*T1}{\Delta p*p2}}$	$k_v=\frac{G}{514}\sqrt{\frac{T1}{\rho_N*\Delta p*p2}}$	$k_v=\frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v=\frac{Q_N}{257p1}\sqrt{\rho_N*T1}$	$k_v=\frac{G}{257p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v=\frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		SERVICE CONDITIONS		
medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	Q [m³/h]	7171,26	8576,38	11769,29
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	35163,00	43910,00	59074,00
charge pressure (abs.)	p1 [bar]	5,38	5,62	5,51
discharge pressure (abs.)	p2 [bar]	5,35	5,59	5,48
pressure loss	Δp [bar]	0,030	0,03	0,03
mass flow	G [kg/h]	45465,76	56775,63	76382,68
medium density	ρ1 [kg/m³]	6,34	6,62	6,49
absolute temp. (inlet side)	T1 [K]	296,10	296,10	296,10
spec. volume at p2 and t1	V2 [m³/kg]	0,16	0,15	0,16
spec. volume at p1/2 and t1	V* [m³/kg]	0,32	0,30	0,31

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	3341,21	4081,80	5546,27
travel (%) (first give Kvs-value!)	74,83	79,95	87,78
selected Kvs-value	Kvs= 8944,00		
valve type	butterfly valve		

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **PK16007** Project No.: K70101
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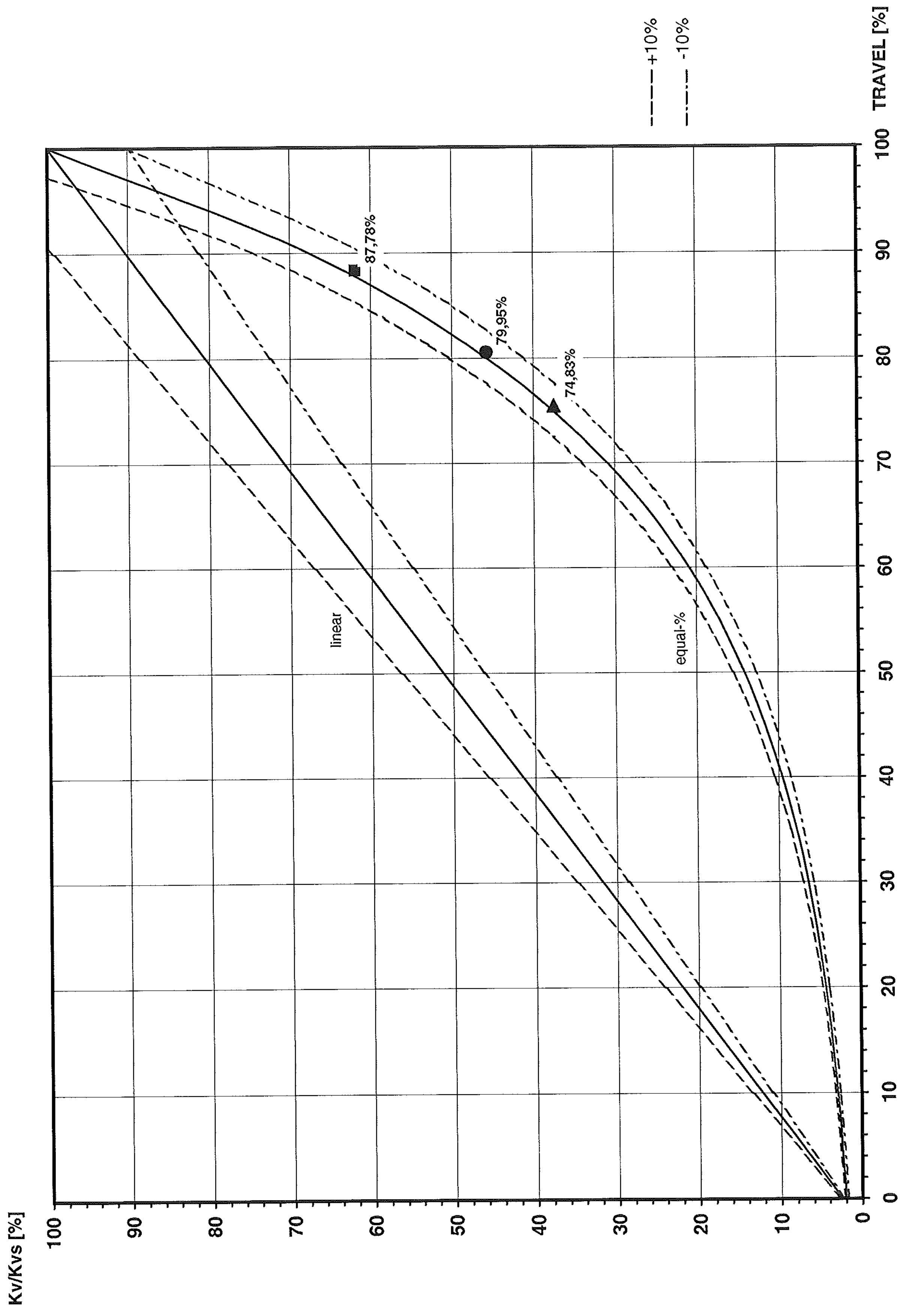

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV16071**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^*\Delta p}}$	$K_v = \frac{G}{\sqrt{1000^*\rho 1^*\Delta p}}$	$K_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^*T1}{\Delta p^*p2}}$	$K_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^*\Delta p^*p2}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257p1}\sqrt{\rho_N{}^*T1}$	$K_v = \frac{G}{257p1}\sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	701,20	844,75	1136,48
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	35163,00	43910,00	59074,00
charge pressure (abs.)	**p1 [bar]**	55,000	57,00	57,00
discharge pressure (abs.)	**p2 [bar]**	25,000	25,00	25,00
pressure loss	**Δp [bar]**	30,000	32,00	32,00
mass flow	**G [kg/h]**	45465,76	56775,63	76382,68
medium density	**ρ1 [kg/m³]**	64,840	67,21	67,21
absolute temp. (inlet side)	**T1 [K]**	298,10	298,10	298,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,03	0,03	0,03
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,03	0,03	0,03
		RESULTS		
		case 1	**case 2**	**case 3**
pressure gradient		supercritical	supercritical	supercritical
flash (%)				
Kv_flash				
Kv_liquid				
Kv_tot		48,84	58,85	79,17
travel (%) (first give Kvs-value!)		69,67	74,43	82,02
selected Kvs-value		**Kvs=**	**160,00**	
valve type		globe valve		

STANDARD DENSITIES OF COMMON GASES		
gas	**chemical symbol**	**density ρ_N kg/m³**
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV16071** Project No.: K70101
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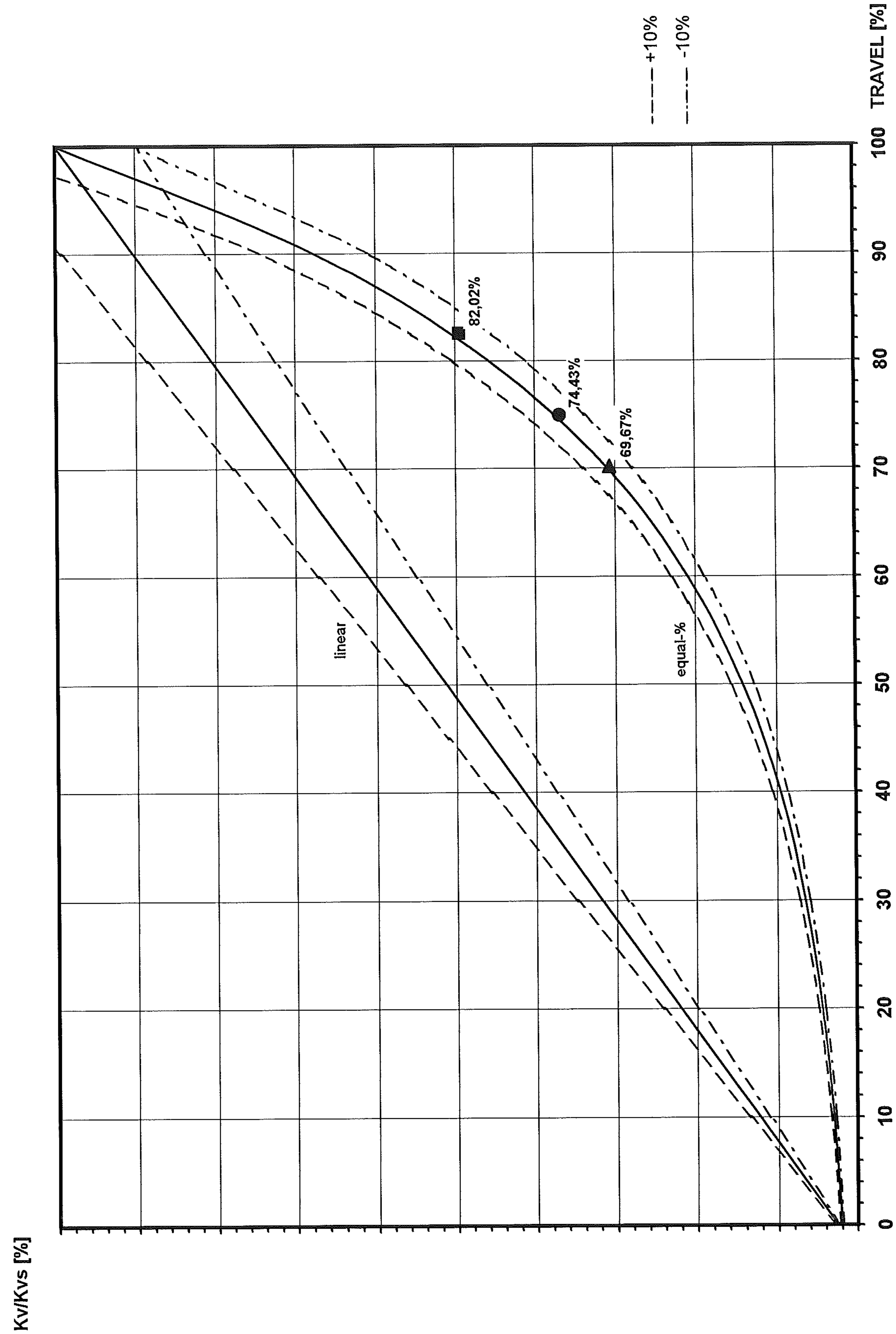


0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HK16073**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	701,20	844,75	1136,48
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	35163,00	43910,00	59074,00
charge pressure (abs.)	**p1 [bar]**	55,00	57,00	57,00
discharge pressure (abs.)	**p2 [bar]**	54,98	56,98	56,98
pressure loss	**Δp [bar]**	0,020	0,02	0,02
mass flow	**G [kg/h]**	45465,76	56775,63	76382,68
medium density	**ρ1 [kg/m³]**	64,84	67,21	67,21
absolute temp. (inlet side)	**T1 [K]**	298,10	298,10	298,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,02	0,02	0,02
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,03	0,03	0,03

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	1280,81	1571,10	2113,67
travel (%) (first give Kvs-value!)	78,24	83,47	91,05
selected Kvs-value	**Kvs=**	**3000,00**	
valve type	**butterfly valve**		

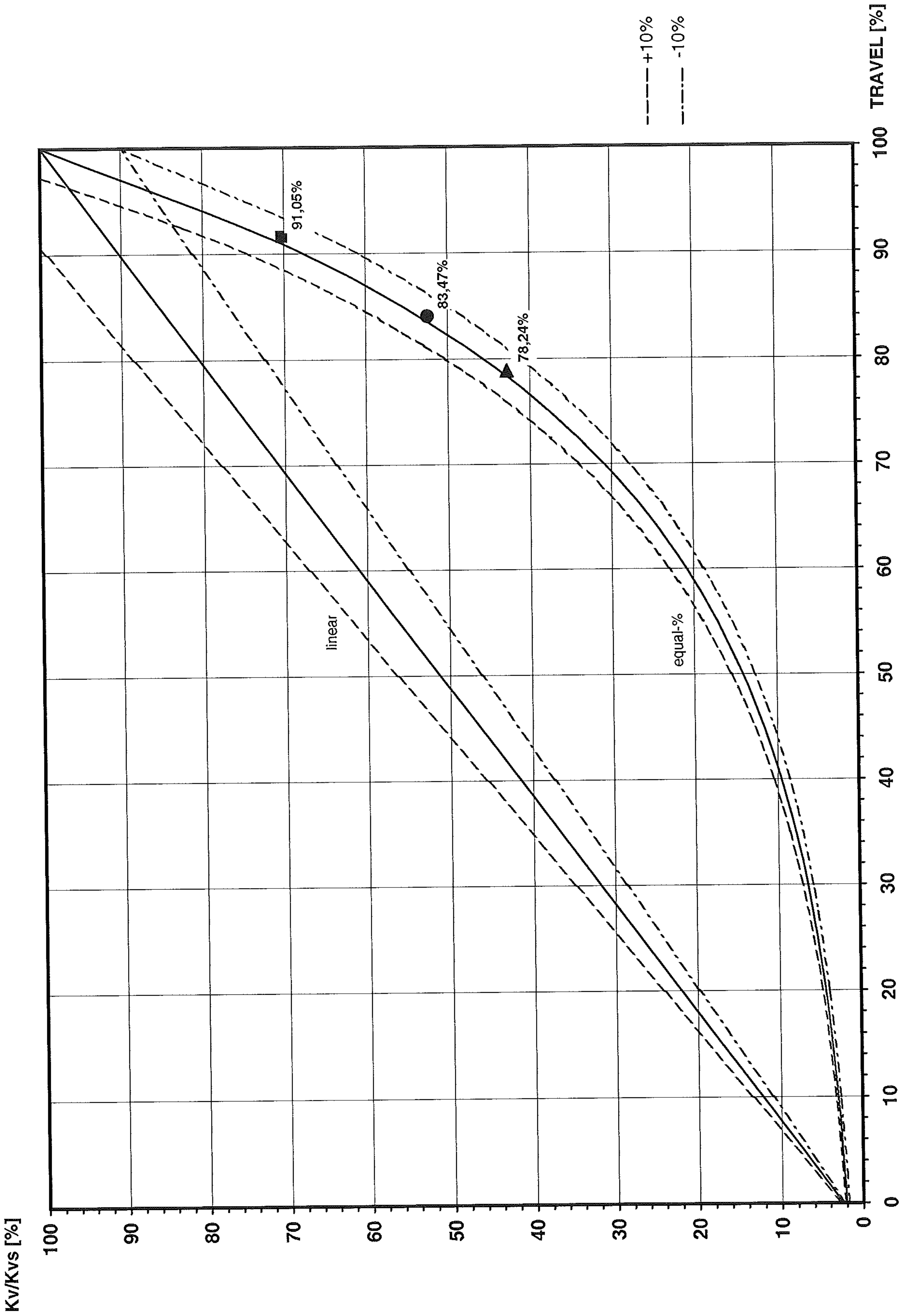
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HK16073** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FV20001** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	180,54	181,74	182,58
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	3500,00	3500,00	3500,00
charge pressure (abs.)	**p1 [bar]**	21,000	21,00	21,00
discharge pressure (abs.)	**p2 [bar]**	20,800	20,80	20,80
pressure loss	**Δp [bar]**	0,200	0,20	0,20
mass flow	**G [kg/h]**	4376,40	4376,40	4376,40
medium density	**ρ1 [kg/m³]**	24,240	24,08	23,97
absolute temp. (inlet side)	**T1 [K]**	293,00	294,80	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,04	0,04	0,04
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,08	0,08	0,08

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	63,90	64,10	64,24
travel (%) (first give Kvs-valuel)	76,54	76,62	76,67
selected Kvs-value	**Kvs=**	**160,00**	
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

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0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FV20001** Project No.: K70101
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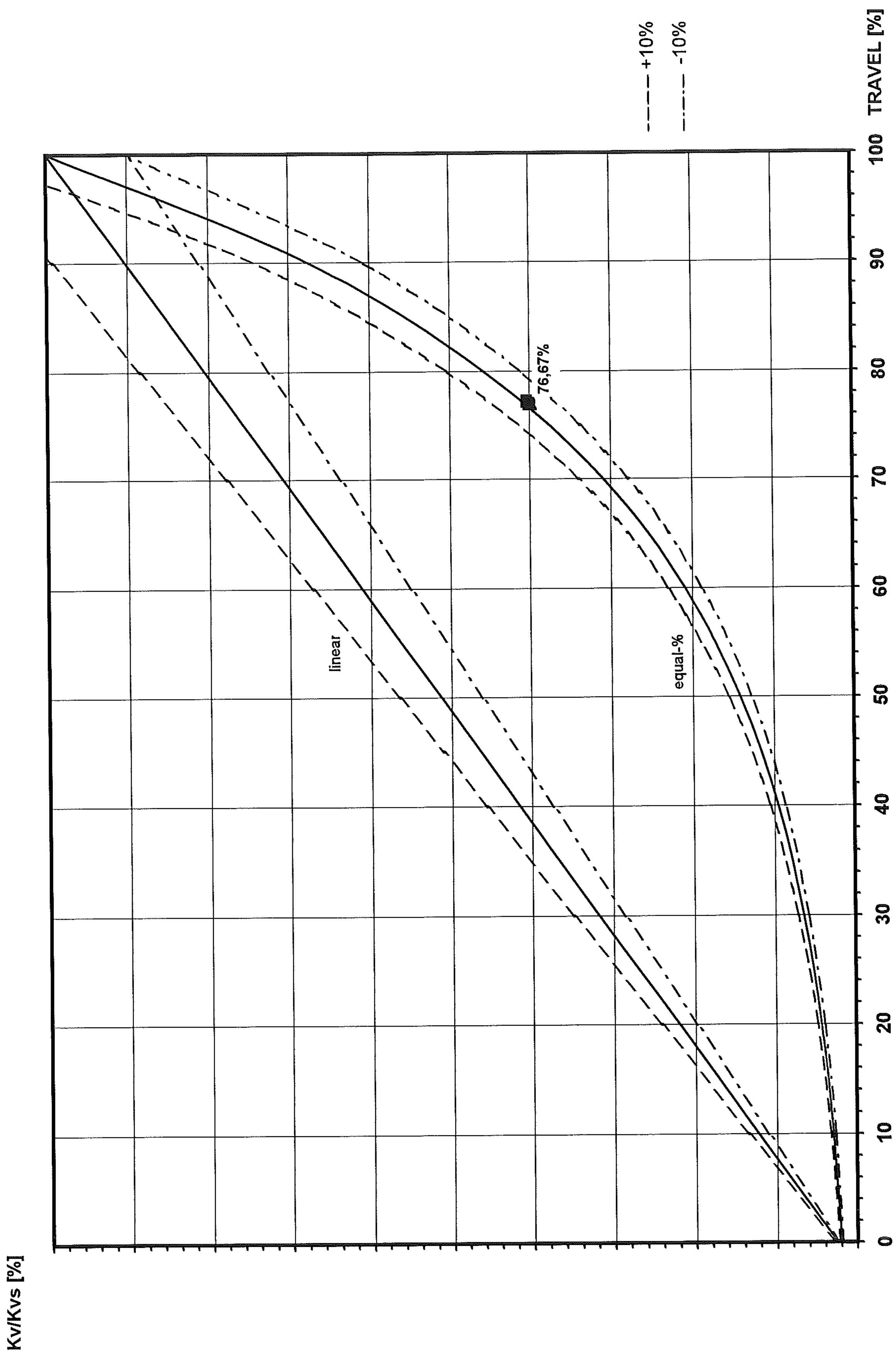

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

FV20001_calc

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AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

TAG - No.:	FV20002
Project-No.:	K70101
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	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	case 2	case 3
volume flow	Q [m³/h]	180,54	181,74	182,58
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	3500,00	3500,00	3500,00
charge pressure (abs.)	p1 [bar]	21,000	21,00	21,00
discharge pressure (abs.)	p2 [bar]	18,000	18,00	18,00
pressure loss	Δp [bar]	3,000	3,00	3,00
mass flow	G [kg/h]	4376,40	4376,40	4376,40
medium density	ρ [kg/m³]	24,240	24,08	23,97
absolute temp. (inlet side)	T1 [K]	293,00	294,80	296,10
spec. volume at p2 and t1	V2 [m³/kg]	0,05	0,05	0,05
spec. volume at p1/2 and t1	V* [m³/kg]	0,08	0,08	0,08

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	17,74	17,79	17,83
travel (%) (first give Kvs-value!)	82,62	82,70	82,76
selected Kvs-value	Kvs=	35,00	
valve type	globe valve		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FV20002** Project No.: K70101
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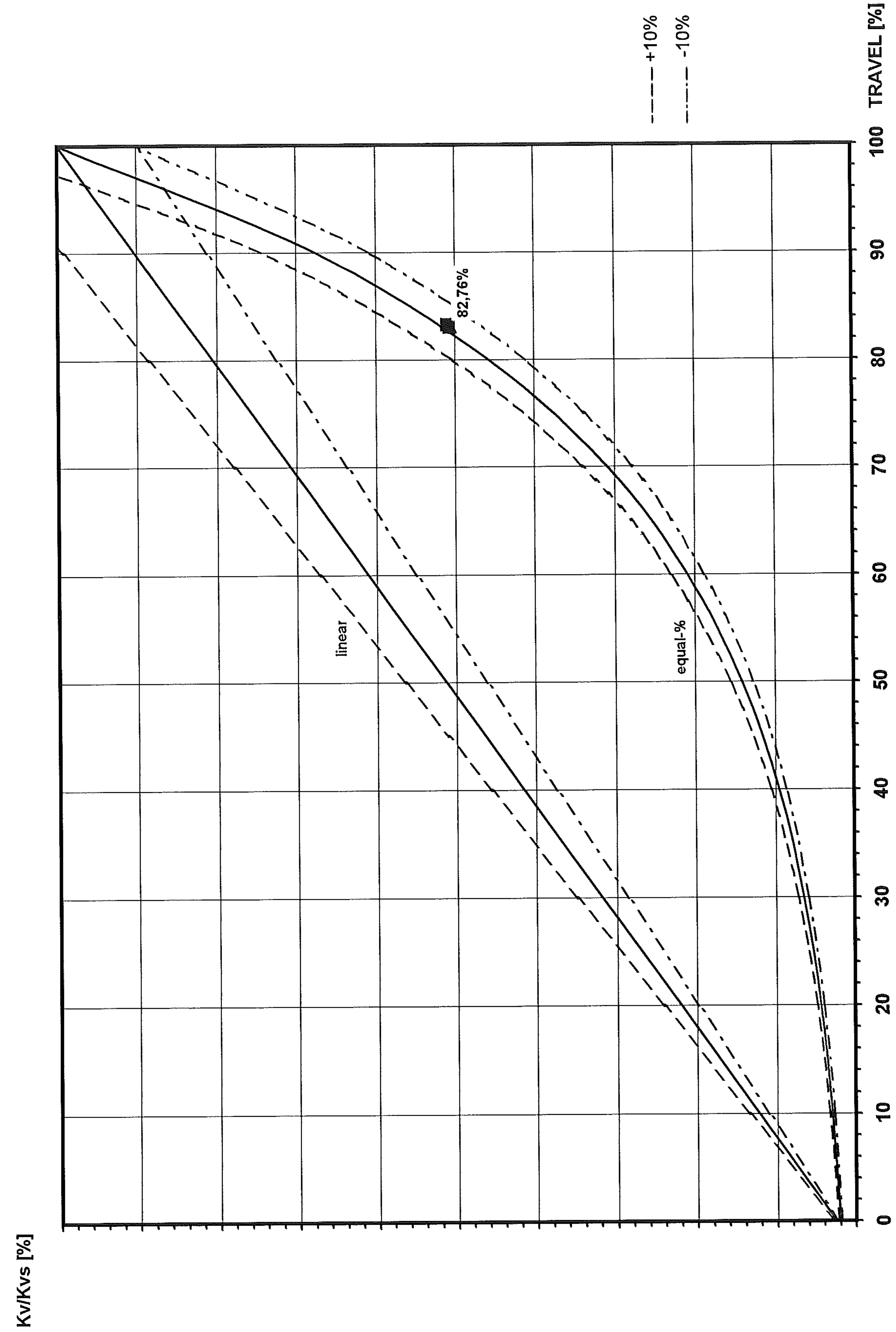

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV20003** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	182,58		
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	3500,00		
charge pressure (abs.)	**p1 [bar]**	21,07		
discharge pressure (abs.)	**p2 [bar]**	21,00		
pressure loss	**Δp [bar]**	0,07		
mass flow	**G [kg/h]**	4376,40		
medium density	**ρ1 [kg/m³]**	23,97		
absolute temp. (inlet side)	**T1 [K]**	296,10		
spec. volume at p2 and t1	**V2 [m³/kg]**	0,04		
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,08		

STANDARD DENSITIES OF COMMON GASES		
gas	**chemical symbol**	**density ρ_N kg/m³**
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical		
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	108,07		
travel (%) (first give Kvs-value!)	89,97		
selected Kvs-value	**Kvs=**	**160,00**	
valve type	globe valve		

Travel indication only depends on valves with equal % characteristic

Required Valve Size:
DN 100

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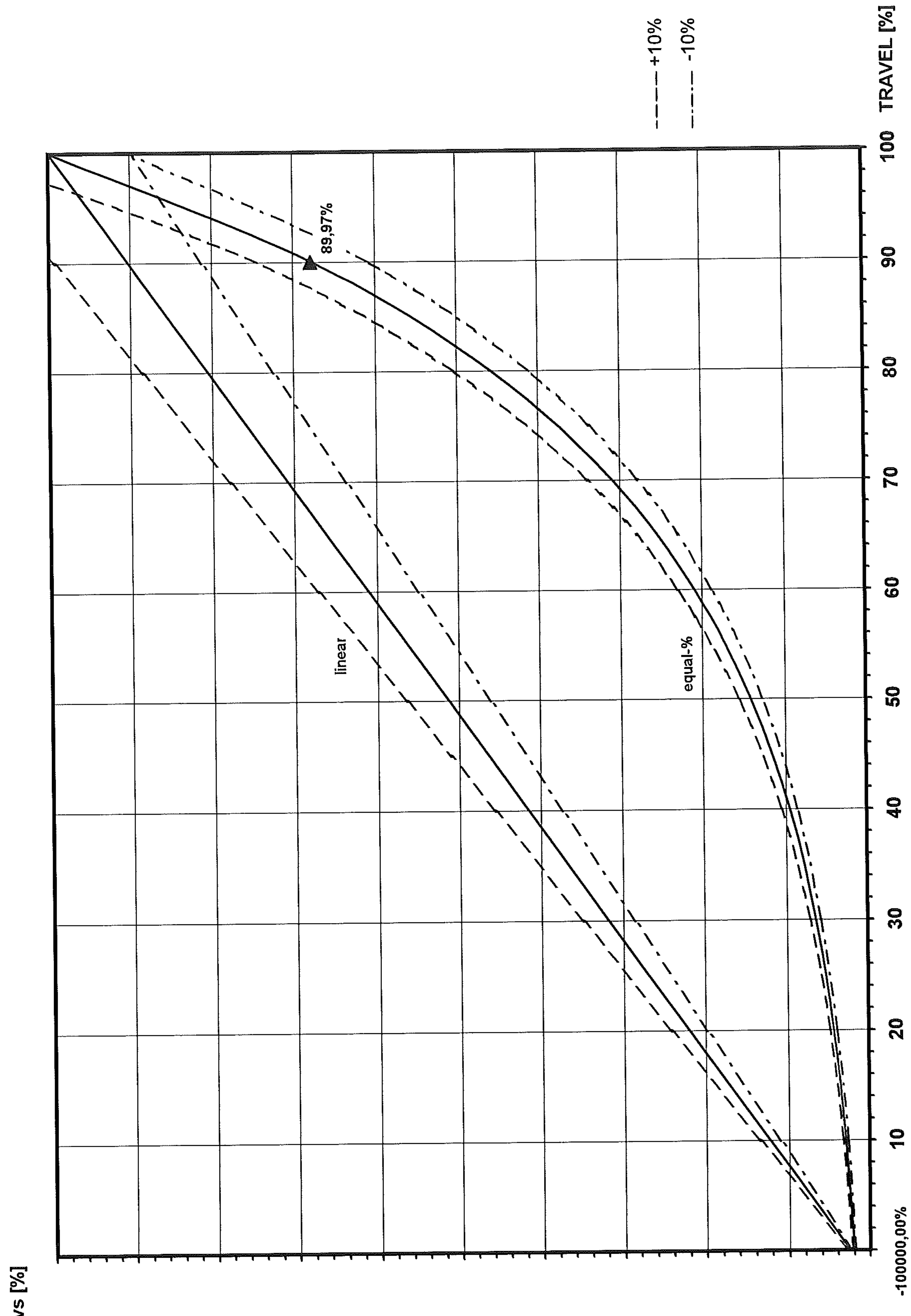
0	02.11.2004	Möller		Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV20003** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	38293	Möller		Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

HV20003_calc

SPEZ80DE.XLS 25.08.1997

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	28614,92	28836,74	29290,87
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	29750,00	29750,00	29750,00
charge pressure (abs.)	**p1 [bar]**	1,15	1,16	1,15
discharge pressure (abs.)	**p2 [bar]**	1,12	1,13	1,12
pressure loss	**Δp [bar]**	0,030	0,03	0,03
mass flow	**G [kg/h]**	37199,40	37199,40	37199,40
medium density	**ρ1 [kg/m³]**	1,30	1,29	1,27
absolute temp. (inlet side)	**T1 [K]**	293,00	294,80	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,78	0,77	0,78
spec. volume at p1/2 and t1	**V* [m³/kg]**	1,51	1,51	1,53

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	6043,83	6035,49	6075,72
travel (%) (first give Kvs-value!)	81,20	81,16	81,33
selected Kvs-value	**Kvs= 12611,00**		
valve type	**butterfly valve**		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

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0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FK20005** Project No.: K70101
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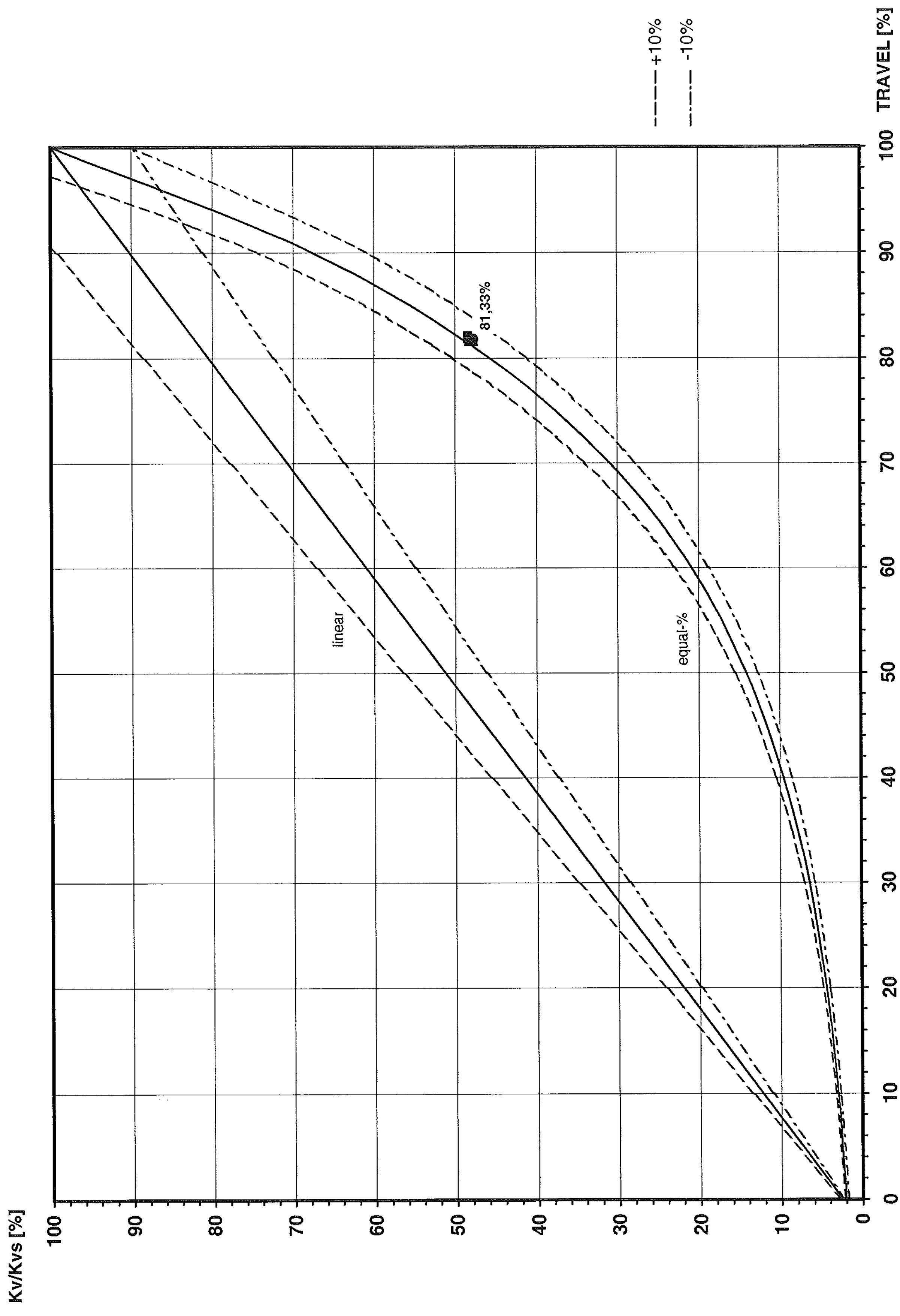

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FK20006** Project-No.: K70101
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calculation of Kv-value	pressure gradient	liquids: flow (m³/h)	liquids: flow (kg/h)	gases: flow (m³/h)	gases: flow (kg/h)	steam: flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	7384,25	14768,50	29290,87
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	7500,00	15000,00	29750,00
charge pressure (abs.)	**p1 [bar]**	1,15	1,15	1,15
discharge pressure (abs.)	**p2 [bar]**	1,11	1,11	1,11
pressure loss	**Δp [bar]**	0,040	0,04	0,04
mass flow	**G [kg/h]**	9378,00	18756,00	37199,40
medium density	**ρ1 [kg/m³]**	1,27	1,27	1,27
absolute temp. (inlet side)	**T1 [K]**	296,10	296,10	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,79	0,79	0,79
spec. volume at p1/2 and t1	**V* [m³/kg]**	1,53	1,53	1,53

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	1332,45	2664,90	5285,38
travel (%) (first give Kvs-value!)	54,07	71,79	89,30
selected Kvs-value	**Kvs=**	**8034,00**	
valve type	**butterfly valve**		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

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0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FK20006** Project No.: K70101
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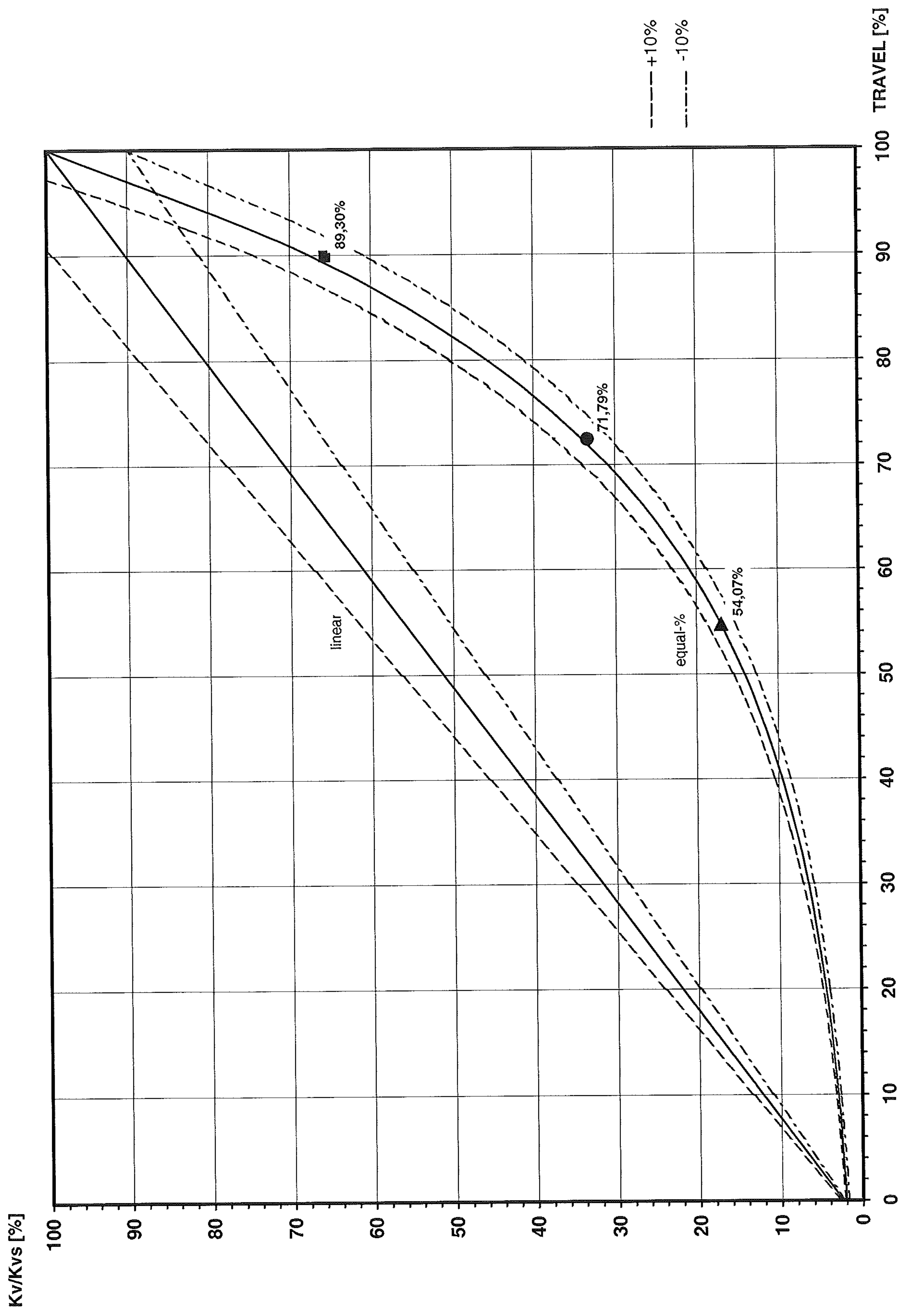

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

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AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **TV20008** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		air		
state		liquid		
standard density		1,2930 kg/m³		
volume flow	Q [m³/h]	40,73	51,36	63,38
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	27793,00	35140,00	44608,00
charge pressure (abs.)	p1 [bar]	54,880	56,83	56,80
discharge pressure (abs.)	p2 [bar]	5,300	5,47	5,40
pressure loss	Δp [bar]	49,580	51,36	51,40
mass flow	G [kg/h]	35936,35	45436,02	57678,14
medium density	ρ1 [kg/m³]	750,000	752,00	728,00
absolute temp. (inlet side)	T1 [K]	106,20	106,00	110,40
spec. volume at p2 and t1	V2 [m³/kg]	0,06	0,06	0,06
spec. volume at p1/2 and t1	V* [m³/kg]	0,01	0,01	0,01

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	supercritical
flash (%)	15,00	15,00	20,00
Kv_flash	3,46	4,23	7,30
Kv_liquid	5,01	6,21	7,54
Kv_tot	8,47	10,44	14,85
travel (%) (first give Kvs-value!)	63,74	69,08	78,08
selected Kvs-value	**Kvs= 35,00**		
valve type	globe valve		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

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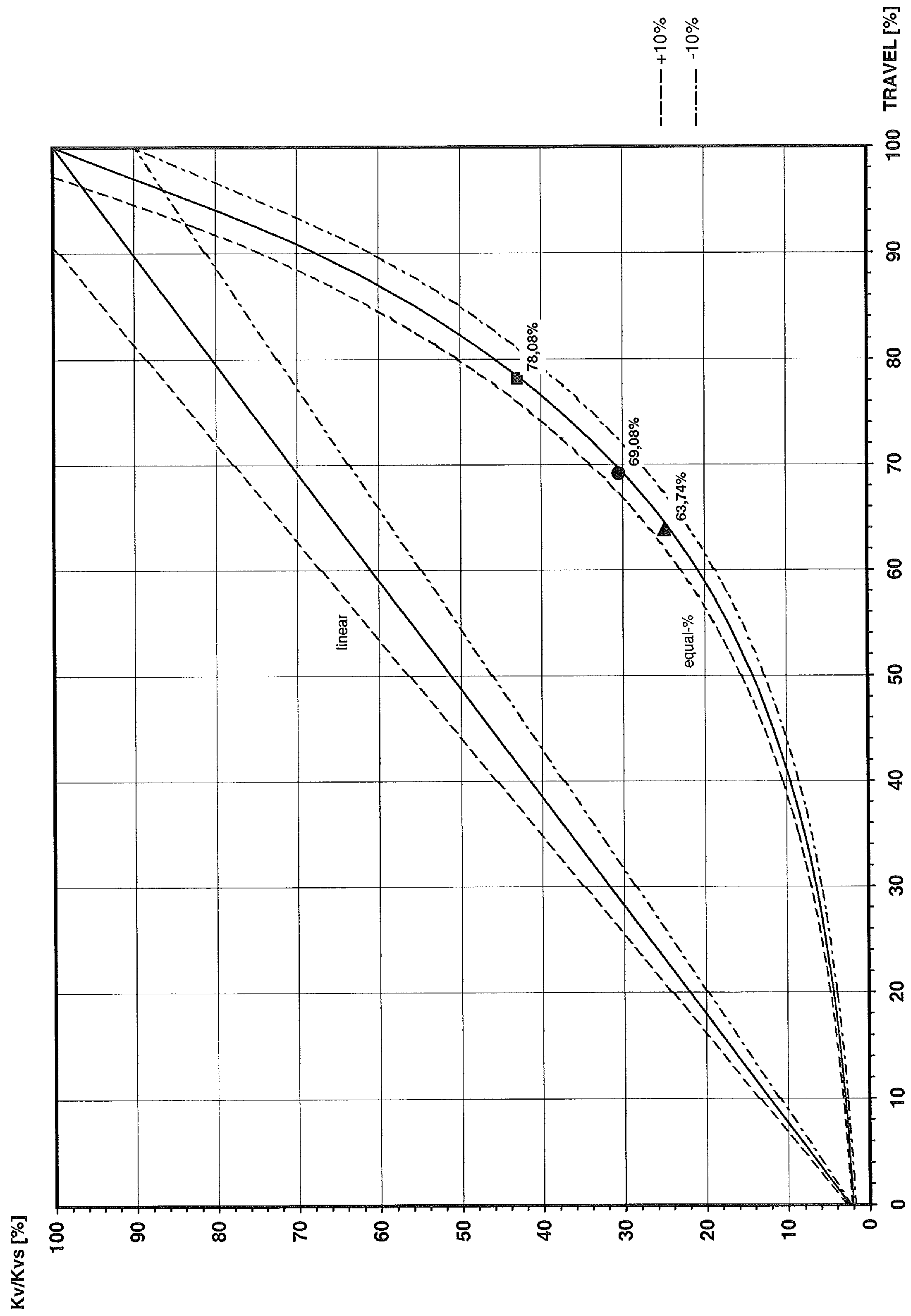
AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **TV20008** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE Air Liquide AGS GmbH	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV20013**
		Project-No.: K70101
	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		oxigen		
state		gaseous		
standard density		1,4290 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	2,86	6,56	14,90
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	200,00	110,00	250,00
charge pressure (abs.)	**p1 [bar]**	28,00	28,00	28,00
discharge pressure (abs.)	**p2 [bar]**	27,80	27,80	27,80
pressure loss	**Δp [bar]**	0,20	0,20	0,20
mass flow	**G [kg/h]**	285,80	157,19	357,25
medium density	**ρ1 [kg/m³]**	100,00	23,97	23,97
absolute temp. (inlet side)	**T1 [K]**	296,10	296,10	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,03	0,03	0,03
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,05	0,05	0,05

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	3,39	1,87	4,24
travel (%) (first give Kvs-value!)	72,38	57,10	78,09
selected Kvs-value	**Kvs=**	**10,00**	
valve type	**globe valve**		

STANDARD DENSITIES OF COMMON GASES

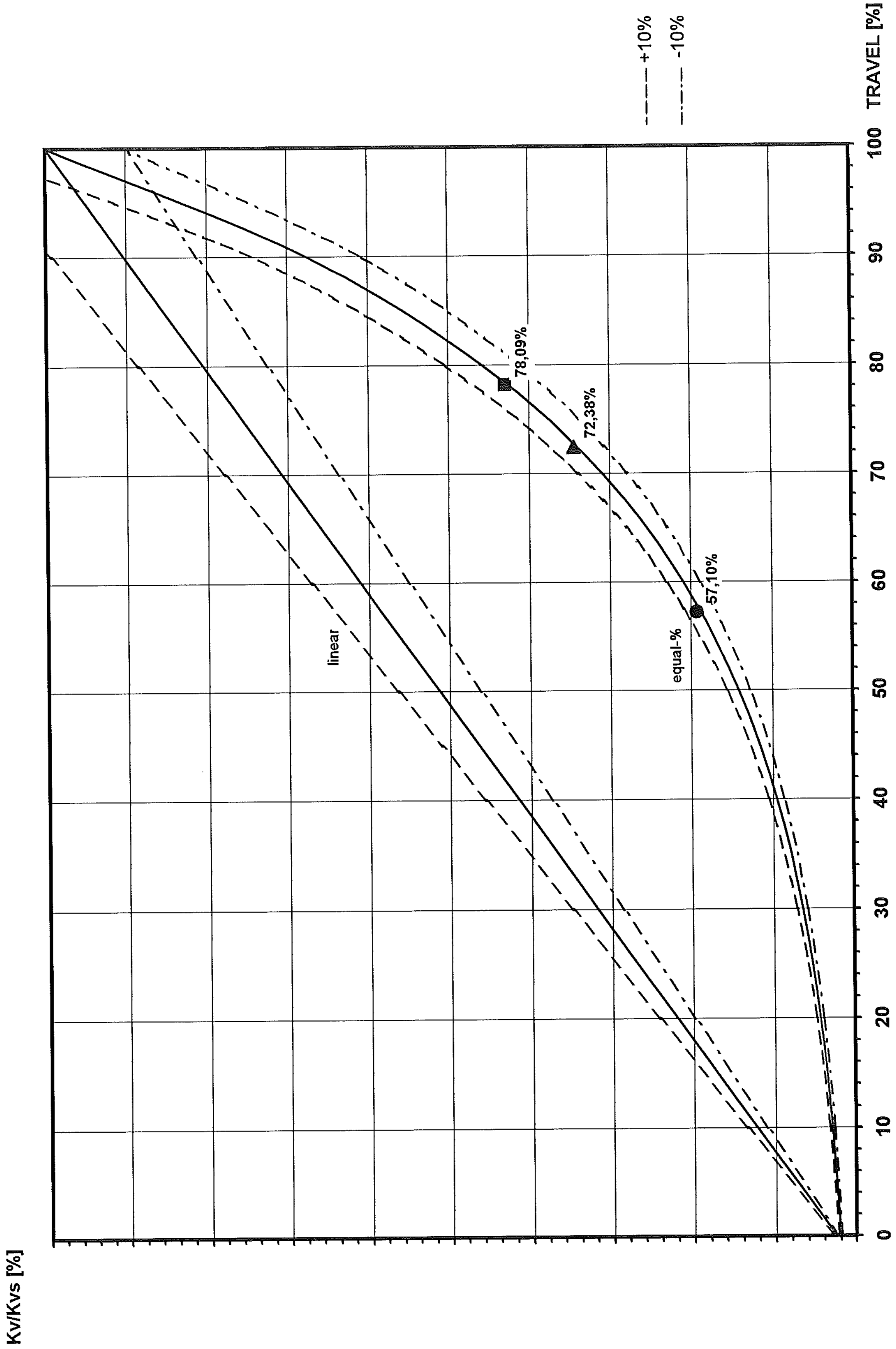
gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel Indication only depends on valves with equal % characteristic

Required Valve Size:
DN 100

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	02.11.2004	Möller		Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV20013** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	38293	Möller		Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

FLOWSERVE Kämmer Ventile	SERIE 035000	Art.-Nr.	1048959		
		Datum	28.01.2005	Name	na

Order: C7310

DN/Size: 25

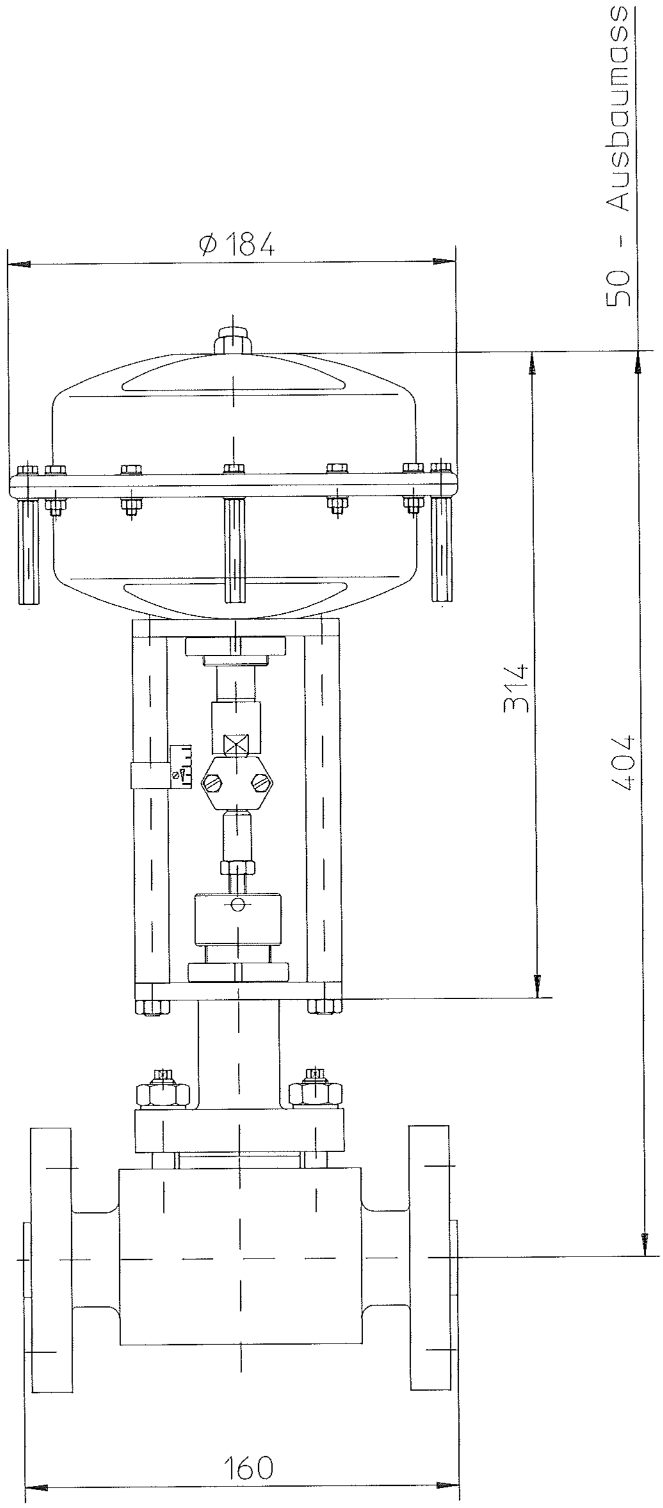
PN/Class: 40

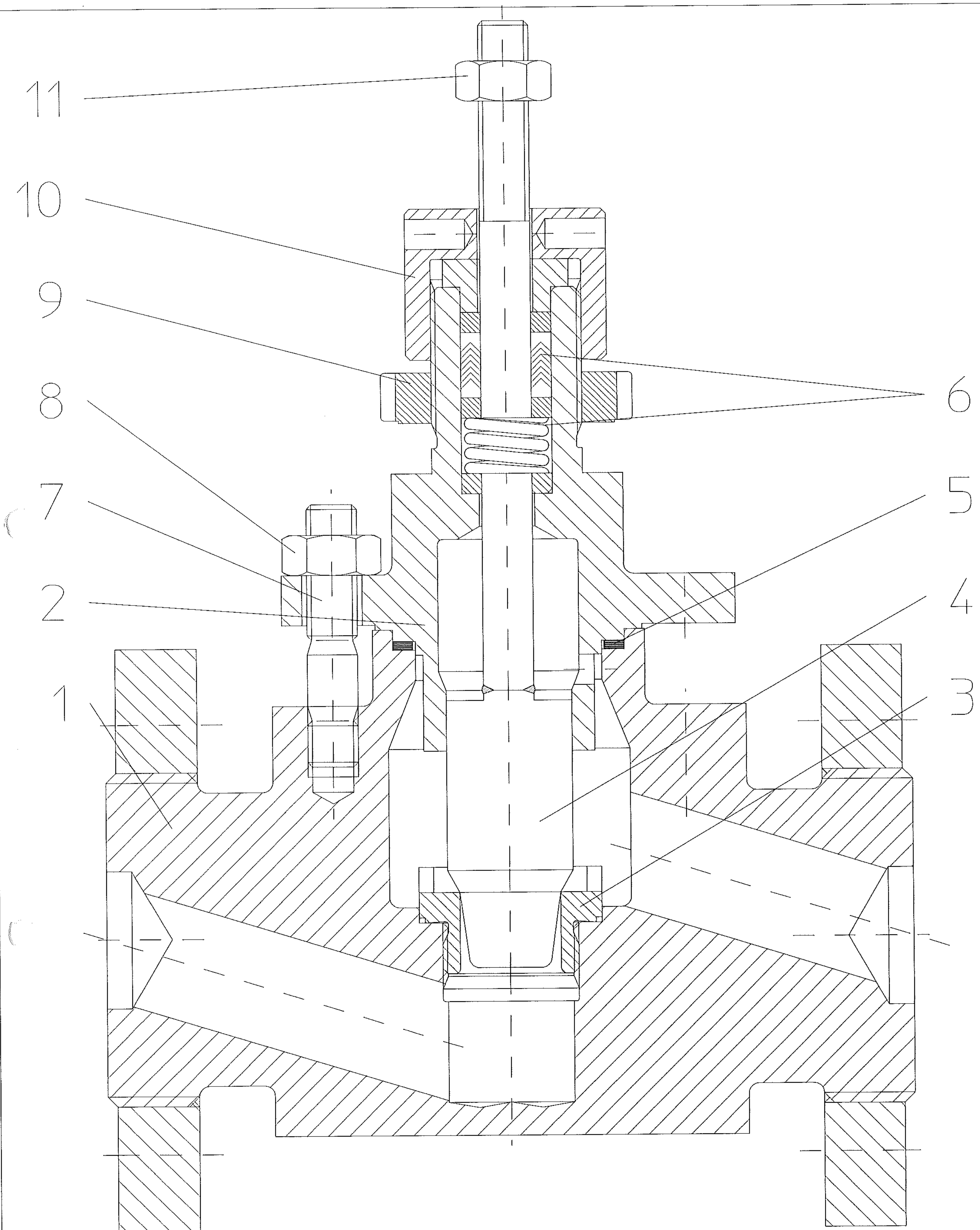
Geh.-Material: 2.4360

Ventiltyp: 350P2

Antrieb: P2-23

Serien-Nr.	Meßstelle
1	HV20013
2	HV20014





FLOWSERVE Kämmer Ventile		Datum	Name	DN_Size 25 · PN_Class 40
	Bearb.	07.02.2005	RK	DURCHGANGSVENTIL FEDERBELASTETE STOPFBUCHSE
	Gepr.	07.02.2005	QU	
	Order			
	Serie	035000		
	alte Nr.:			DIN A 4 · 1049071 · Maßstab 1:1
Rev. · Änderungs-Nr. · Datum · Name	Blatt	Bl.		Ersetzt: · Ersetzt durch:

TEIL	BENENNUNG	WERKSTOFF	ST.	ART./ZEICHN.NR.
11	6-KT MUTTER M10	A2	4	0100336A2
10	ÜBERWURFMUTTER M30x1.5	1.4305	1	025530605
9	NUTMUTTER M30x1.5	A2	1	0100387A2
8	6-KT MUTTER M10	A2	4	0100336A2
7	STIFTSCHRAUBE M10X40	A2	4	0101324A2
6	PACKUNG-KOMPLETT FEDERBEL.	PTFE	1	025602500
5	DICHTUNG	PTFE	1	0*355351PT
4	SPINDEL MIT KEGEL	2.4360	1	*019891
3	SITZRING	2.4360	1	1012056
2	AUFSATZ	2.4360	1	1012055
1	GEHÄUSE DN25 PN40 FORM C	2.4360	1	1049044

FLOWSERVE
Kämmer Ventile

	Datum	Name
Bearb.	07.02.2005	RK
Gepr.	07.02.2005	QU
Order		
Serie	035000	

DN_Size 25 | PN_Class 40

STÜCKLISTE
DURCHGANGSVENTIL

ZUSAMMENSTELLUNG 1049071

DIN A 4

1049071

Maßstab 1:1

Rev.	Änderungs-Nr.	Datum	Name	Blatt	Bl.	Ersetzt:	Ersetzt durch:

Schutzvermerk nach DIN 34 Beachten

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK20013** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^*\Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^*T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
	medium	oxigen		
	state	gaseous		
	standard density	1,4290 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	285,80	655,78	1490,40
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	20000,00	11000,00	25000,00
charge pressure (abs.)	**p1 [bar]**	28,00	28,00	28,00
discharge pressure (abs.)	**p2 [bar]**	27,80	27,80	27,80
pressure loss	**Δp [bar]**	0,20	0,20	0,20
mass flow	**G [kg/h]**	28580,00	15719,00	35725,00
medium density	**ρ1 [kg/m³]**	100,00	23,97	23,97
absolute temp. (inlet side)	**T1 [K]**	296,10	296,10	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,03	0,03	0,03
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,05	0,05	0,05
		RESULTS		
		case 1	**case 2**	**case 3**
	pressure gradient	subcritical	subcritical	subcritical
	flash (%)			
	Kv_flash			
	Kv_liquid			
	Kv_tot	339,44	186,69	424,30
	travel (%) (first give Kvs-value!)	84,19	68,91	89,90
	selected Kvs-value	**Kvs=**	**630,00**	
	valve type	**globe valve**		

STANDARD DENSITIES OF COMMON GASES

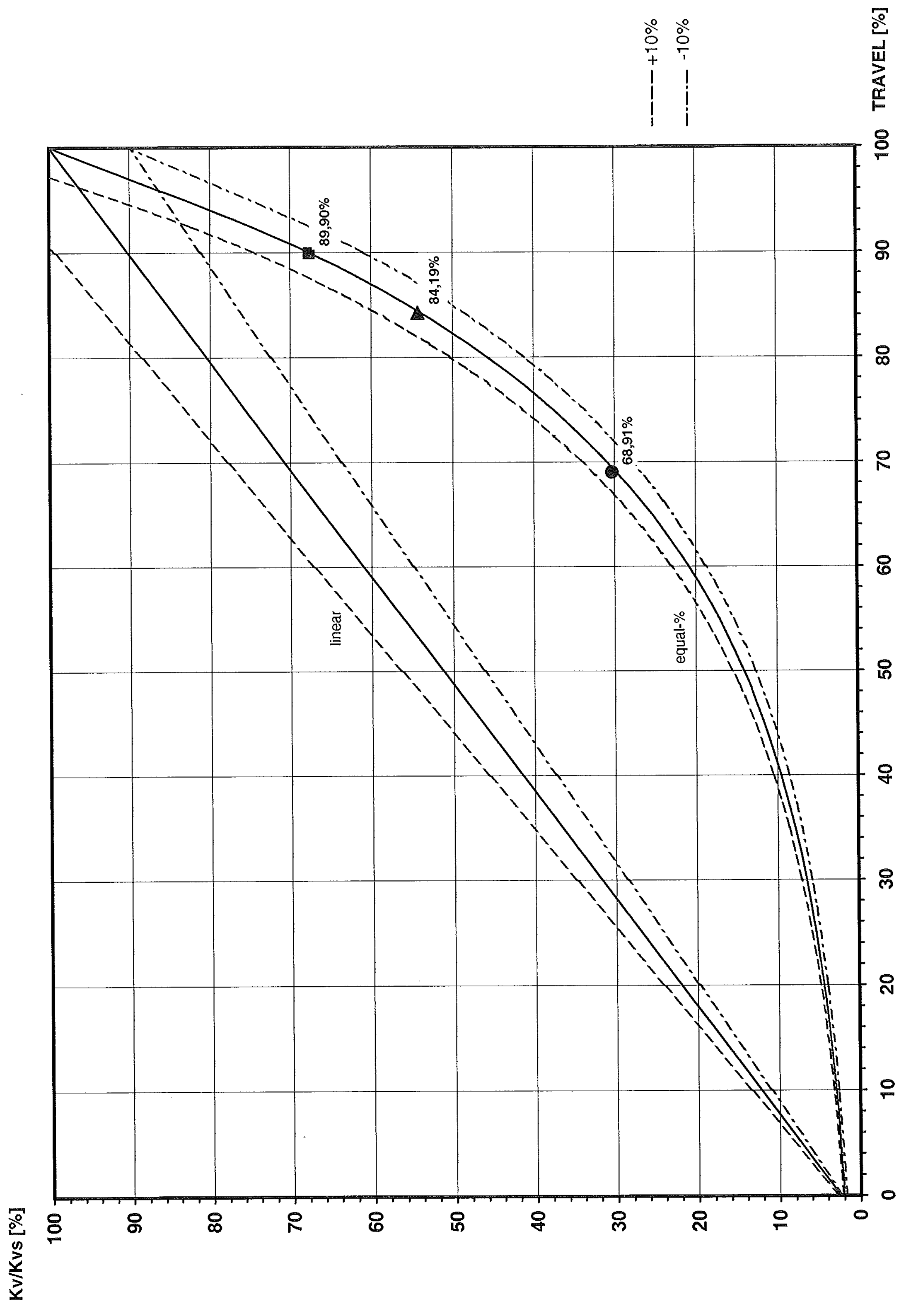
gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Required Valve Size:
DN 100

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	02.11.2004	Möller		Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK20013** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	38293	Möller		Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

UK20013_calc.XLS

SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK20026** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	4648,65	10052,59	10271,53
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	22686,00	51468,00	51874,00
charge pressure (abs.)	**p1 [bar]**	5,36	5,62	5,54
discharge pressure (abs.)	**p2 [bar]**	5,34	5,60	5,52
pressure loss	**Δp [bar]**	0,020	0,02	0,02
mass flow	**G [kg/h]**	29333,00	66548,12	67073,08
medium density	**ρ1 [kg/m³]**	6,31	6,62	6,53
absolute temp. (inlet side)	**T1 [K]**	296,10	296,10	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,16	0,15	0,15
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,32	0,30	0,31

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	2642,58	5854,42	5943,20
travel (%) (first give Kvs-value!)	68,83	89,17	89,55
selected Kvs-value	**Kvs=**	**8944,00**	
valve type	**butterfly valve**		

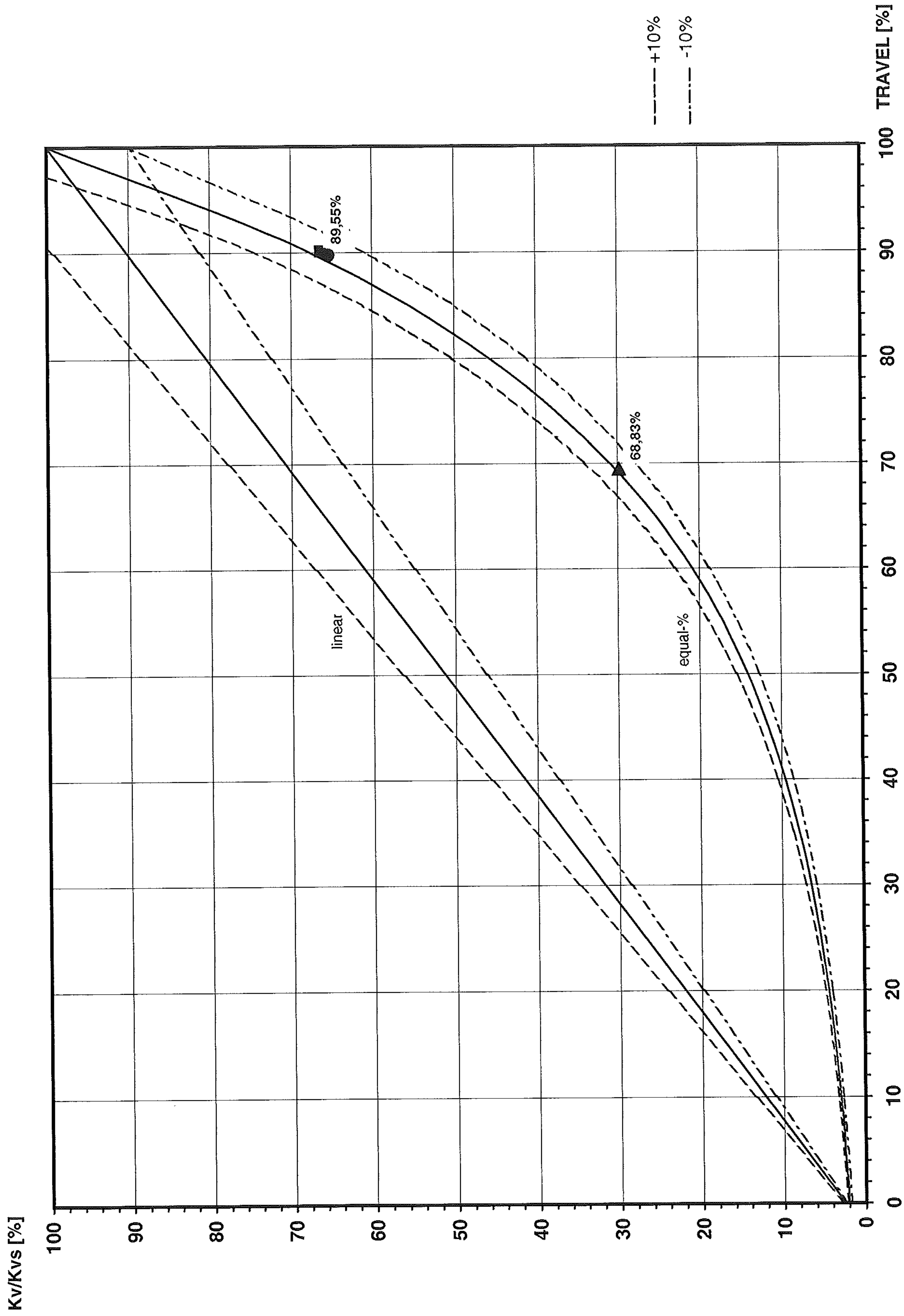
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK20026** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **UK20027**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1}\sqrt{\rho_N^* T1}$	$k_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		SERVICE CONDITIONS		
medium		air		
state		gaseous		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	Q [m³/h]	1967,16	1875,05	990,05
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	9600,00	9600,00	5000,00
charge pressure (abs.)	p1 [bar]	5,62	5,62	5,62
discharge pressure (abs.)	p2 [bar]	1,01	3,30	5,60
pressure loss	Δp [bar]	4,607	2,32	0,02
mass flow	G [kg/h]	12412,80	12412,80	6465,00
medium density	ρ1 [kg/m³]	6,31	6,62	6,53
absolute temp. (inlet side)	T1 [K]	296,10	296,10	296,10
spec. volume at p2 and t1	V2 [m³/kg]	0,84	0,26	0,15
spec. volume at p1/2 and t1	V* [m³/kg]	0,30	0,30	0,30

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	supercritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	130,05	132,08	568,74
travel (%) (first give Kvs-value!)	57,38	57,77	95,10
selected Kvs-value	**Kvs=**	**689,00**	
valve type	butterfly valve		

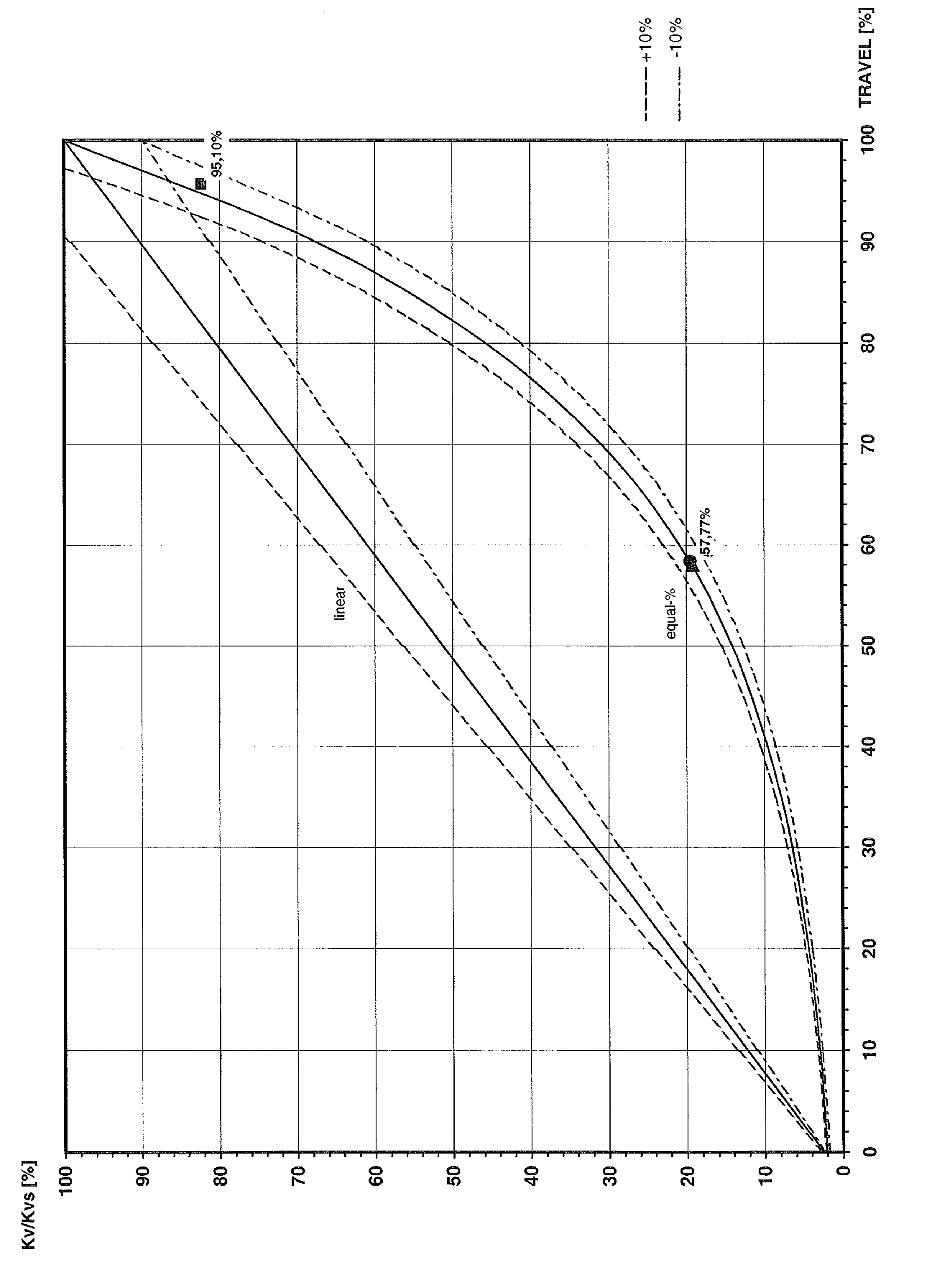
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **UK20027** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT21003** Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: SUMP HP-COLUMN	

SERVICE CLOX

Temperature T = **-174,1** °C
Service Density ρ_M = **822** kg/m³

GAS ABOVE LIQUID GAN

Temperature T = **-174,1** °C
Pressure (abs.) P = **5,46** bar
Gas Density ρ_G = **21,3** kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES GAN

Ambient Temperature T_U = **15** °C
Filling Density ρ_F = **6,4** kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1) a = mm
Distance between L+ and L- Nozzle (see fig. 2) e = **3698** mm

From L+ Nozzle to 0% Level H1 b = **0** mm
From L+ Nozzle to 100% Level H2 d = **3698** mm
From H1 to H2 c = **3698** mm

CALCULATION ACCORDING TO

○ **Fig. 1**

$$P_{H1}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

$$P_{H2}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

Diff. Press. 0% **P_{H1} =** **mbar**

Diff. Press. 100% **P_{H2} =** **mbar**

Span **P_{H2-H1} =** **mbar**

◉ **Fig. 2**

$$P_{H1}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm}+\frac{\rho_G}{kg/m^3}\cdot\frac{(e-b)}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

$$P_{H2}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm}+\frac{\rho_G}{kg/m^3}\cdot\frac{(e-d)}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

Diff. Press. 0% **P_{H1} =** **5,403** **mbar**

Diff. Press. 100% **P_{H2} =** **295,777** **mbar**

Span **P_{H2-H1} =** **290,374** **mbar**

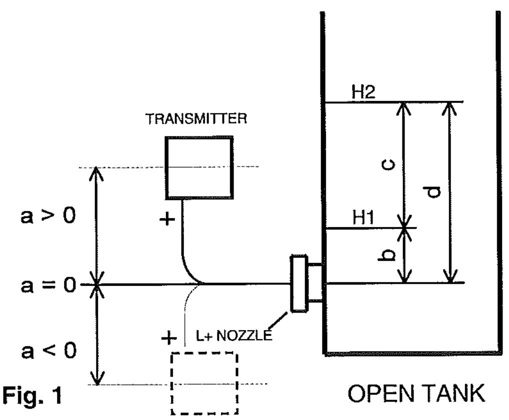


Fig. 1 OPEN TANK

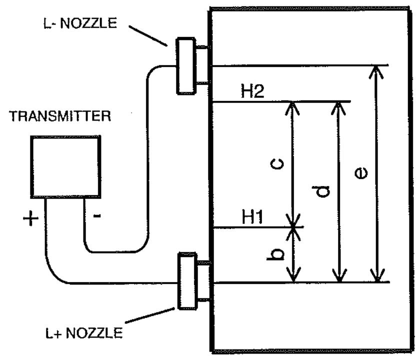


Fig. 2 CLOSED TANK

REMARKS

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.03.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT21060**
		Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: AIR SEPARATOR	

SERVICE LIQUID AIR

Temperature	T =	-175,6	°C
Service Density	ρ_M =	780	kg/m³

GAS ABOVE LIQUID AIR

Temperature	T =	-168	°C
Pressure (abs.)	P =	5,47	bar
Gas Density	ρ_G =	20,3	kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES AIR

Ambient Temperature	T_U =	15	°C
Filling Density	ρ_F =	6,62	kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1)	a =		mm
Distance between L+ and L- Nozzle (see fig. 2)	e =	2360	mm
From L+ Nozzle to 0% Level H1	b =	0	mm
From L+ Nozzle to 100% Level H2	d =	2360	mm
From H1 to H2	c =	2360	mm

CALCULATION ACCORDING TO

○ **Fig. 1**

$$P_{H1}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5} mbar$$

$$P_{H2}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5} mbar$$

Diff. Press. 0%	P_{H1} =		mbar
Diff. Press. 100%	P_{H2} =		mbar
Span	P_{H2-H1} =		mbar

◉ **Fig. 2**

$$P_{H1}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm}+\frac{\rho_G}{kg/m^3}\cdot\frac{(e-b)}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5} mbar$$

$$P_{H2}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm}+\frac{\rho_G}{kg/m^3}\cdot\frac{(e-d)}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5} mbar$$

Diff. Press. 0%	P_{H1} =	3,166	mbar
Diff. Press. 100%	P_{H2} =	178,989	mbar
Span	P_{H2-H1} =	175,823	mbar

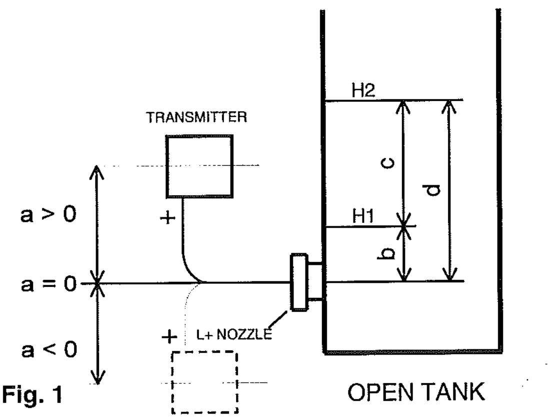


Fig. 1

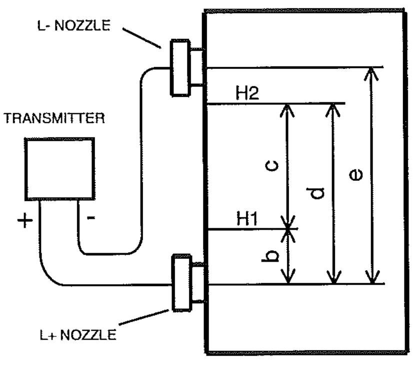


Fig. 2

REMARKS

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.03.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	# Specification Calculation of Control (Butterfly-)Valves	TAG - No.: **LV21003**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	46,25		74,48
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	31986,00		47247,00
charge pressure (abs.)	**p1 [bar]**	5,020		5,20
discharge pressure (abs.)	**p2 [bar]**	3,690		2,50
pressure loss	**Δp [bar]**	1,330		2,70
mass flow	**G [kg/h]**	45707,99		67515,96
medium density	**ρ1 [kg/m³]**	840,000		834,00
absolute temp. (inlet side)	**T1 [K]**	96,20		96,70
spec. volume at p2 and t1	**V2 [m³/kg]**	0,07		0,10
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,10		0,10

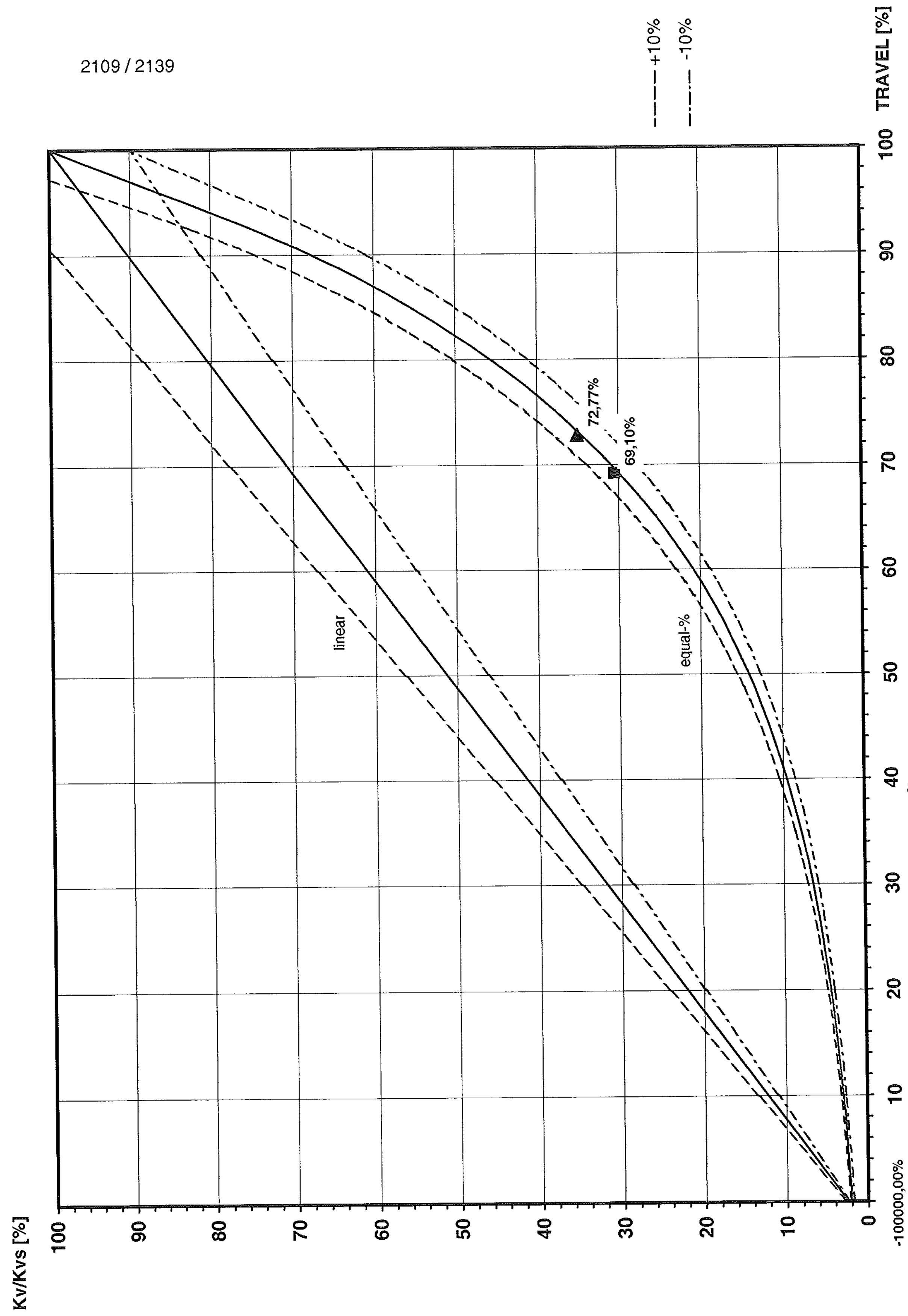
	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical		supercritical
flash (%)	15,00		8,00
Kv_flash	49,40		33,25
Kv_liquid	36,76		41,39
Kv_tot	86,16		74,64
travel (%) (first give Kvs-value!)	72,77		69,10
selected Kvs-value	**Kvs=**	**250,00**	
valve type	globe valve		

STANDARD DENSITIES OF COMMON GASES		
gas	**chemical symbol**	**density ρ_N kg/m³**
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV21003** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



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0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

LV21003_calc.XLS

SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV21006** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	47,33	62,64	65,58
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	27251,00	36017,00	37658,00
charge pressure (abs.)	**p1 [bar]**	5,205	5,29	5,33
discharge pressure (abs.)	**p2 [bar]**	5,170	5,26	5,30
pressure loss	**Δp [bar]**	0,035	0,03	0,03
mass flow	**G [kg/h]**	34074,65	45035,66	47087,56
medium density	**ρ1 [kg/m³]**	720,000	719,00	718,00
absolute temp. (inlet side)	**T1 [K]**	94,50	94,70	94,80
spec. volume at p2 and t1	**V2 [m³/kg]**	0,05	0,05	0,05
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,11	0,11	0,11

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

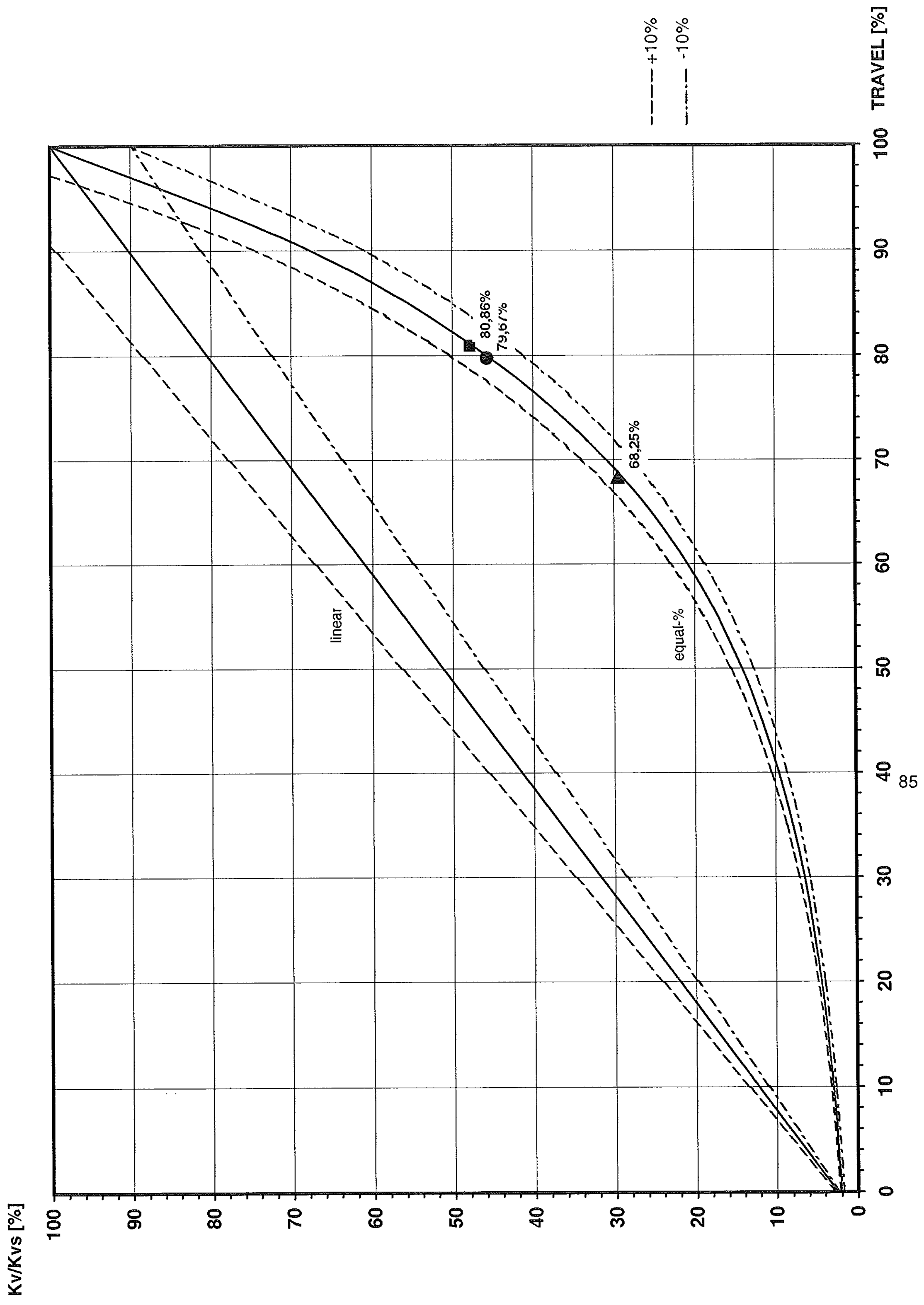
RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	213,69	334,13	349,94
Kv_tot	213,69	334,13	349,94
travel (%) (first give Kvs-value!)	68,25	79,67	80,86
selected Kvs-value	**Kvs=**	**740,00**	
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV21006** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV21014**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		air		
state		liquid		
standard density		1,2930 kg/m³		
volume flow	Q [m³/h]	16,24	21,84	25,93
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	9819,00	13160,00	15644,00
charge pressure (abs.)	p1 [bar]	5,415	5,54	5,58
discharge pressure (abs.)	p2 [bar]	5,290	5,42	5,46
pressure loss	Δp [bar]	0,125	0,12	0,12
mass flow	G [kg/h]	12695,97	17015,88	20227,69
medium density	ρ1 [kg/m³]	782,000	779,00	780,00
absolute temp. (inlet side)	T1 [K]	97,00	97,30	97,40
spec. volume at p2 and t1	V2 [m³/kg]	0,05	0,05	0,05
spec. volume at p1/2 and t1	V* [m³/kg]	0,10	0,10	0,10

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	40,60	54,61	64,84
Kv_tot	40,60	54,61	64,84
travel (%) (first give Kvs-value!)	64,94	72,52	76,91
selected Kvs-value	**Kvs= 160,00**		
valve type	globe valve		

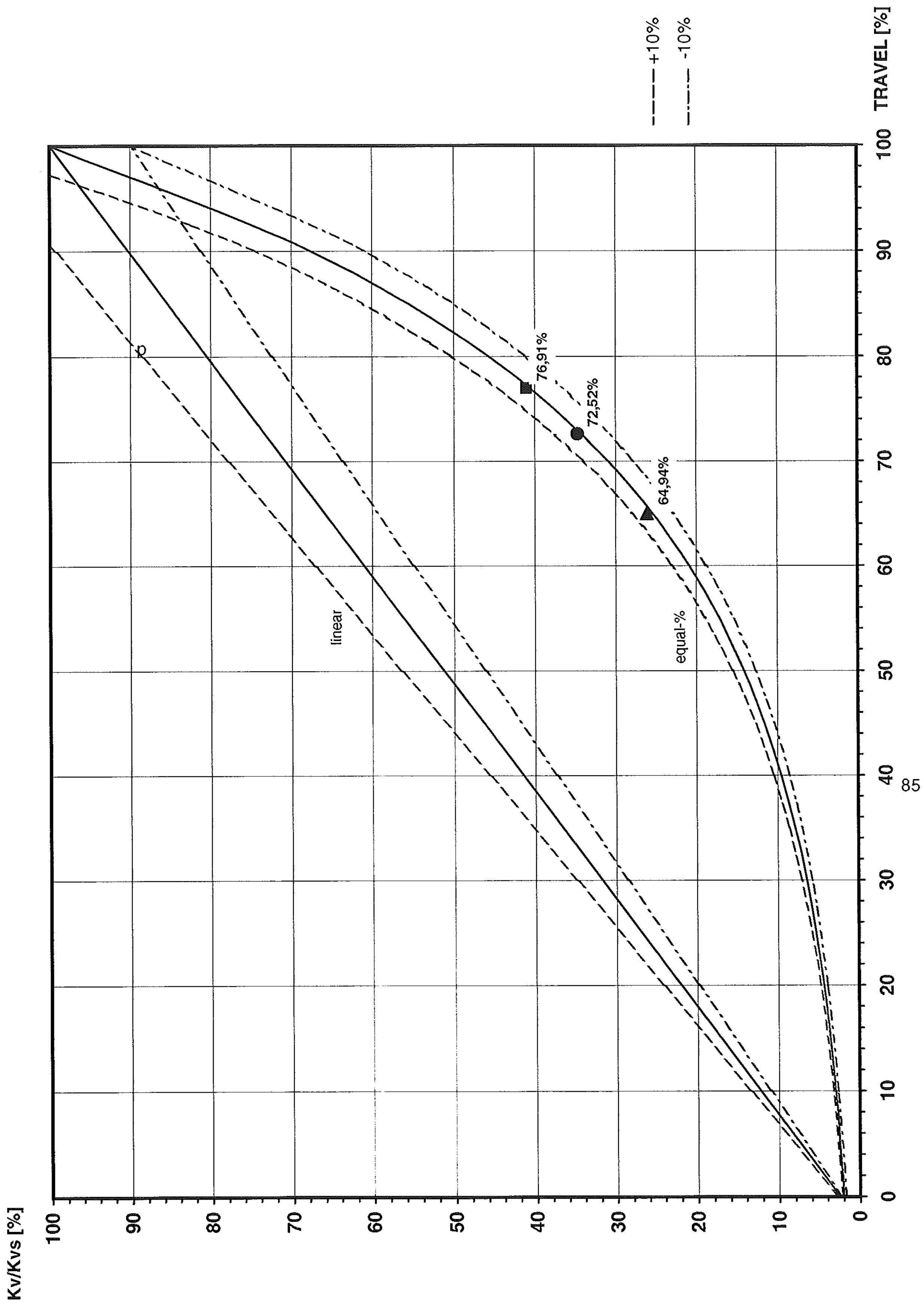
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV21014** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **LV21060** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^*\sqrt{\frac{\rho 1}{1000^*\Delta p}}$	$k_v = \frac{G}{\sqrt{1000^*\rho 1^*\Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^*T1}{\Delta p^*p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^*\Delta p^*p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257p1}\sqrt{\rho_N{}^*T1}$	$k_v = \frac{G}{257p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		air		
state		liquid		
standard density		1,2930 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	23,21		35,03
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	14736,00		22326,00
charge pressure (abs.)	**p1 [bar]**	5,430		5,49
discharge pressure (abs.)	**p2 [bar]**	3,550		2,73
pressure loss	**Δp [bar]**	1,880		2,76
mass flow	**G [kg/h]**	19053,65		28867,52
medium density	**ρ1 [kg/m³]**	821,000		824,00
absolute temp. (inlet side)	**T1 [K]**	89,00		89,60
spec. volume at p2 and t1	**V2 [m³/kg]**	0,07		0,09
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,09		0,09

	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical		supercritical
flash (%)			
Kv_flash			
Kv_liquid	15,34		19,14
Kv_tot	15,34		19,14
travel (%) (first give Kvs-value!)	63,88		69,55
selected Kvs-value	**Kvs= 63,00**		
valve type	**globe valve**		

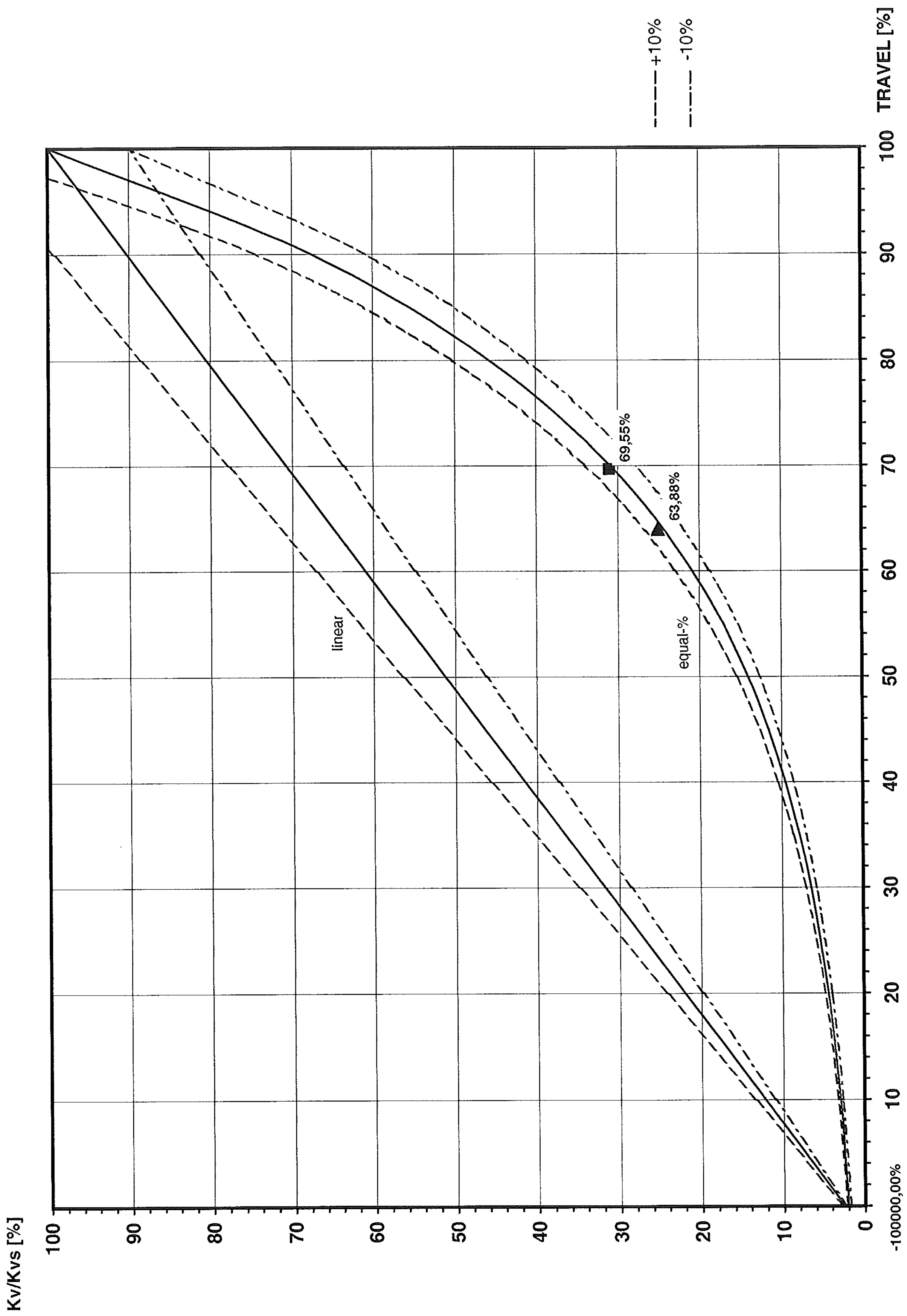
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV21060** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT22001** Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: SUMP LP-COLUMN	

SERVICE LOX

Temperature	T =	-180	°C
Service Density	ρ_M =	1127	kg/m³

GAS ABOVE LIQUID GOX

Temperature	T =	-180	°C
Pressure (abs.)	P =	1,38	bar
Gas Density	ρ_G =	5,9	kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES GOX

Ambient Temperature	T_U =	15	°C
Filling Density	ρ_F =	1,85	kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1)	a =		mm
Distance between L+ and L- Nozzle (see fig. 2)	e =	6823	mm
From L+ Nozzle to 0% Level H1	b =	0	mm
From L+ Nozzle to 100% Level H2	d =	6823	mm
From H1 to H2	c =	6823	mm

CALCULATION ACCORDING TO

○ Fig. 1

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{b}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{a}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{d}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{a}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

Diff. Press. 0%	P_{H1} =		mbar
Diff. Press. 100%	P_{H2} =		mbar
Span	P_{H2-H1} =		mbar

◉ Fig. 2

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{b}{mm} + \frac{\rho_G}{kg/m^3} \cdot \frac{(e-b)}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{e}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{d}{mm} + \frac{\rho_G}{kg/m^3} \cdot \frac{(e-d)}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{e}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

Diff. Press. 0%	P_{H1} =	2,710	mbar
Diff. Press. 100%	P_{H2} =	752,847	mbar
Span	P_{H2-H1} =	750,137	mbar

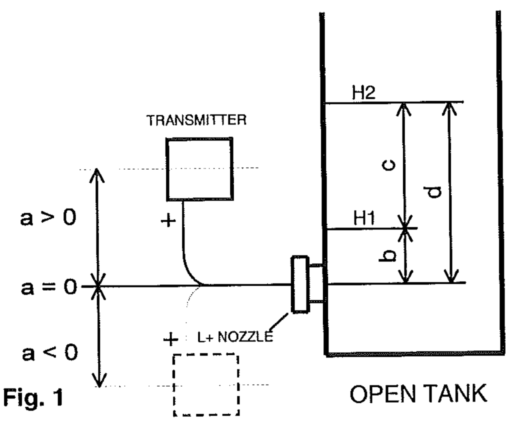


Fig. 1 OPEN TANK

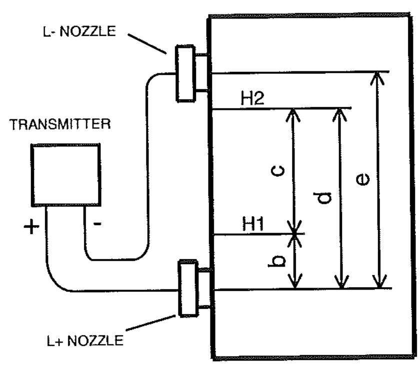


Fig. 2 CLOSED TANK

REMARKS

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.03.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT22011** Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: LP-COLUMN MAIN CONDENSER	

SERVICE LOX

Temperature $T =$ **-180** °C
Service Density $\rho_M =$ **1127** kg/m³

GAS ABOVE LIQUID GOX

Temperature $T =$ **-180** °C
Pressure (abs.) $P =$ **1,38** bar
Gas Density $\rho_G =$ **5,9** kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES GOX

Ambient Temperature $T_U =$ **15** °C
Filling Density $\rho_F =$ **1,85** kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1) a = mm
Distance between L+ and L- Nozzle (see fig. 2) e = **1576** mm

From L+ Nozzle to 0% Level H1 b = **0** mm
From L+ Nozzle to 100% Level H2 d = **1576** mm
From H1 to H2 c = **1576** mm

CALCULATION ACCORDING TO

○ **Fig. 1**

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{b}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{a}{mm} \right) \cdot 9{,}81 \cdot 10^{-3} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{d}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{a}{mm} \right) \cdot 9{,}81 \cdot 10^{-3} mbar$$

Diff. Press. 0% **P_{H1} =** **mbar**

Diff. Press. 100% **P_{H2} =** **mbar**

Span **P_{H2-H1} =** **mbar**

◉ **Fig. 2**

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{b}{mm} + \frac{\rho_G}{kg/m^3} \cdot \frac{(e-b)}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{e}{mm} \right) \cdot 9{,}81 \cdot 10^{-3} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{d}{mm} + \frac{\rho_G}{kg/m^3} \cdot \frac{(e-d)}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{e}{mm} \right) \cdot 9{,}81 \cdot 10^{-3} mbar$$

Diff. Press. 0% **P_{H1} =** **0,626** **mbar**

Diff. Press. 100% **P_{H2} =** **173,895** **mbar**

Span **P_{H2-H1} =** **173,269** **mbar**

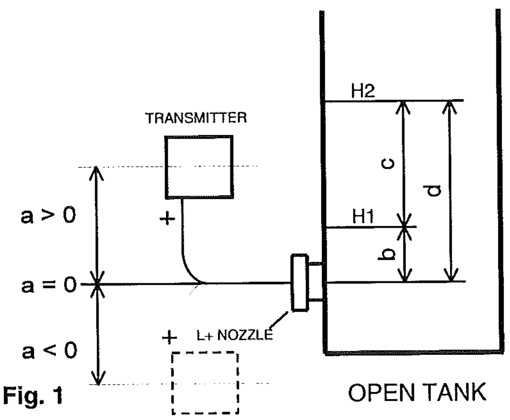


Fig. 1 OPEN TANK

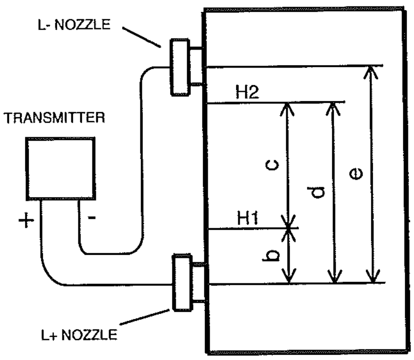


Fig. 2 CLOSED TANK

REMARKS

0	17.03.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

TAG - No.: **LV22001**

Project-No.: K70101

Project: **ASU No. 9 KOSICE**

Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
volume flow	**Q [m³/h]**	3,81	5,08	
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	3000,00	4000,00	
charge pressure (abs.)	**p1 [bar]**	29,000	29,00	
discharge pressure (abs.)	**p2 [bar]**	2,203	2,20	
pressure loss	**Δp [bar]**	26,797	26,80	
mass flow	**G [kg/h]**	4287,00	5716,00	
medium density	**ρ1 [kg/m³]**	1124,000	1125,00	
absolute temp. (inlet side)	**T1 [K]**	95,00	94,80	
spec. volume at p2 and t1	**V2 [m³/kg]**	0,11	0,11	
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,02	0,02	

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	
flash (%)			
Kv_flash			
Kv_liquid	0,78	1,04	
Kv_tot	0,78	1,04	
travel (%) (first give Kvs-value!)	58,25	65,59	
selected Kvs-value	Kvs=	4,00	
valve type	globe valve		

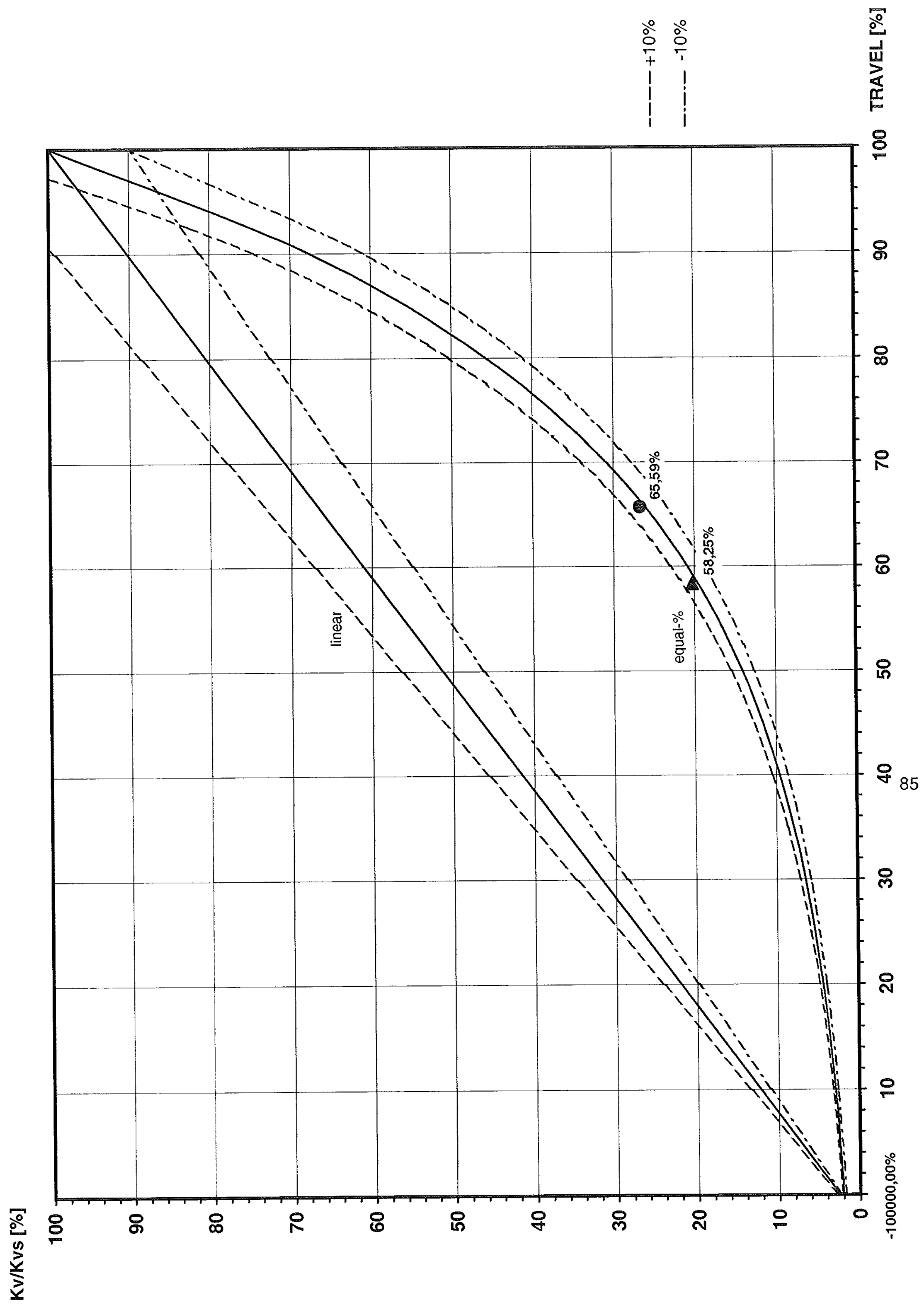
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV22001** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FV22013** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids: flow (m³/h)	liquids: flow (kg/h)	gases: flow (m³/h)	gases: flow (kg/h)	steam: flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1}\sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	32,73	46,30	46,34
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	20629,00	29102,00	29130,00
charge pressure (abs.)	**p1 [bar]**	4,590	4,71	4,73
discharge pressure (abs.)	**p2 [bar]**	4,315	4,32	4,32
pressure loss	**Δp [bar]**	0,275	0,39	0,41
mass flow	**G [kg/h]**	25794,50	36389,14	36424,15
medium density	**ρ1 [kg/m³]**	788,000	786,00	786,00
absolute temp. (inlet side)	**T1 [K]**	81,20	81,60	81,60
spec. volume at p2 and t1	**V2 [m³/kg]**	0,06	0,06	0,06
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,10	0,10	0,10

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	55,37	65,35	63,81
Kv_tot	55,37	65,35	63,81
travel (%) (first give Kvs-value!)	72,87	77,11	76,50
selected Kvs-value	**Kvs=**	**160,00**	
valve type	globe valve		

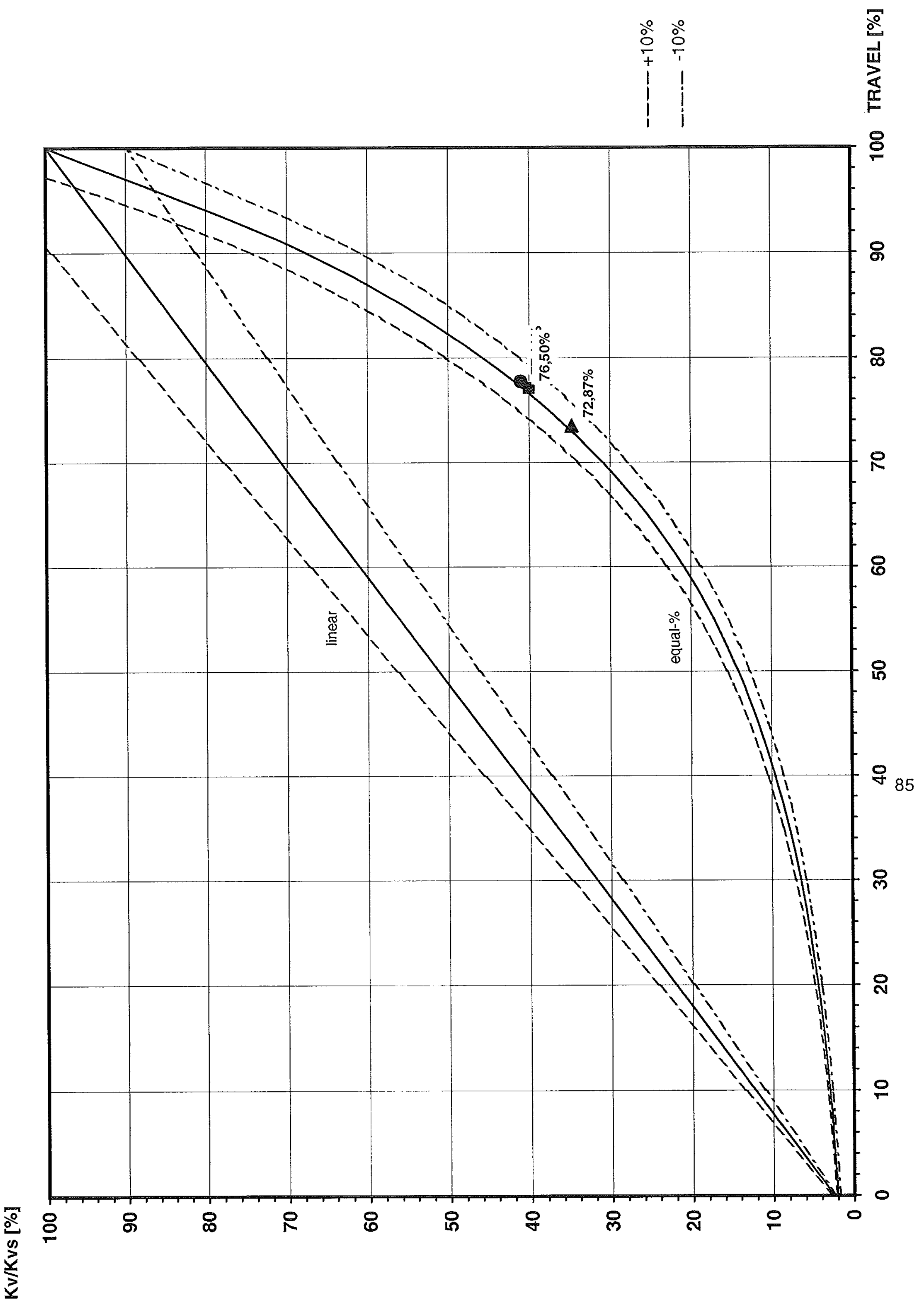
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FV22013** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **LV22030** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	Q [m³/h]	6,28		
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	5000,00		
charge pressure (abs.)	p1 [bar]	2,827		
discharge pressure (abs.)	p2 [bar]	2,029		
pressure loss	Δp [bar]	0,798		
mass flow	G [kg/h]	7145,00		
medium density	ρ1 [kg/m³]	1137,000		
absolute temp. (inlet side)	T1 [K]	91,20		
spec. volume at p2 and t1	V2 [m³/kg]	0,12		
spec. volume at p1/2 and t1	V* [m³/kg]	0,17		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

85

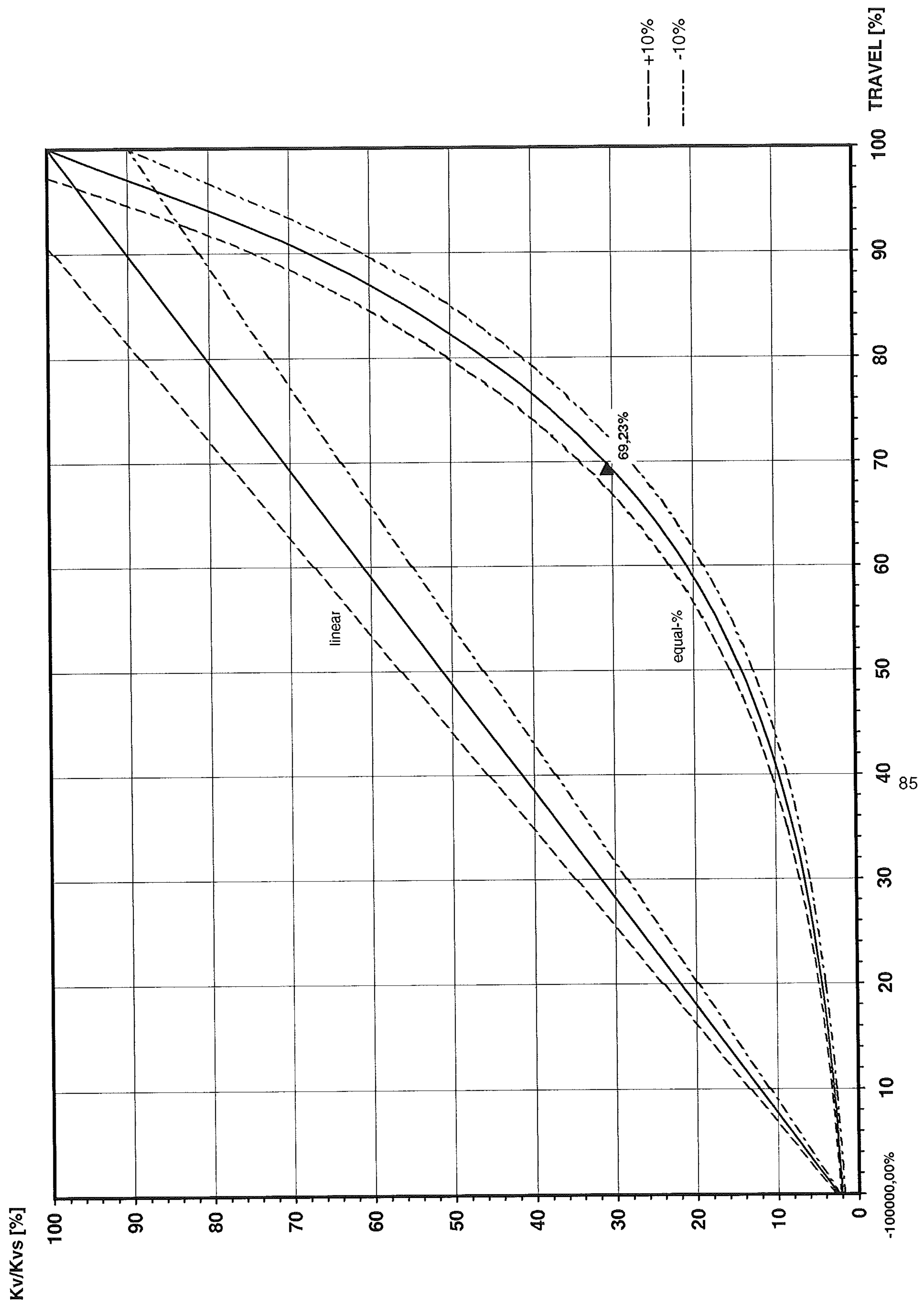
RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	subcritical		
flash (%)			
Kv_flash			
Kv_liquid	7,50		
Kv_tot	7,50		
travel (%) (first give Kvs-value!)	69,23		
selected Kvs-value	**Kvs= 25,00**		
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV22030** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

LV22030_calc.XLS

SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FV22043** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		oxygen		
state		gaseous		
standard density		1,4290 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	12,93	51,74	129,34
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	50,00	200,00	500,00
charge pressure (abs.)	**p1 [bar]**	1,300	1,30	1,30
discharge pressure (abs.)	**p2 [bar]**	1,290	1,29	1,29
pressure loss	**Δp [bar]**	0,010	0,01	0,01
mass flow	**G [kg/h]**	71,45	285,80	714,50
medium density	**ρ1 [kg/m³]**	5,524	5,52	5,52
absolute temp. (inlet side)	**T1 [K]**	93,10	93,10	93,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,19	0,19	0,19
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,37	0,37	0,37

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	9,88	39,52	98,79
travel (%) (first give Kvs-value!)	28,81	64,25	87,67
selected Kvs-value	**Kvs=**	**160,00**	
valve type	globe valve		

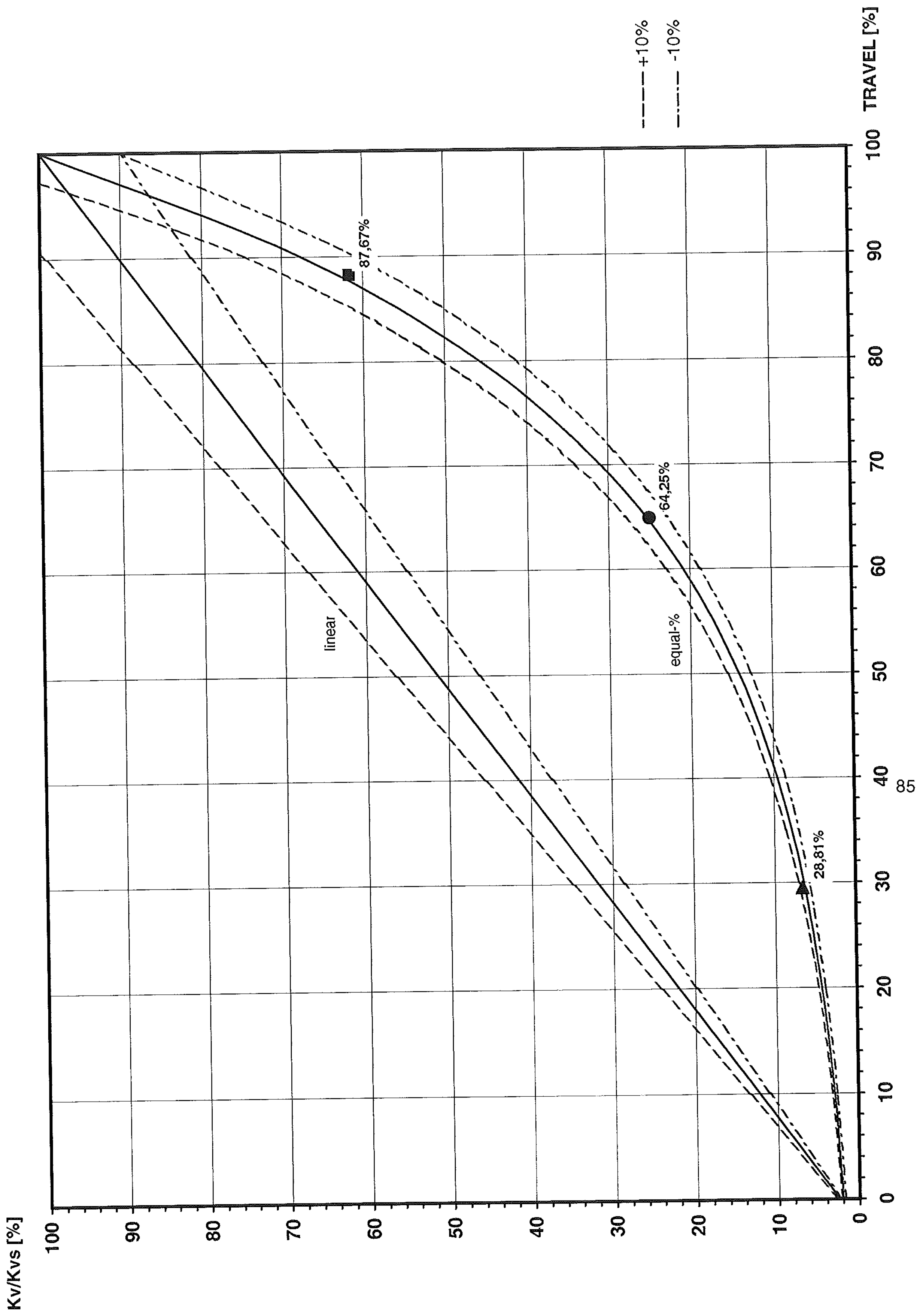
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FV22043** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FV23013** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^*T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	4,77	6,53	
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	3000,00	4100,00	
charge pressure (abs.)	**p1 [bar]**	5,905	5,88	
discharge pressure (abs.)	**p2 [bar]**	2,094	2,09	
pressure loss	**Δp [bar]**	3,812	3,79	
mass flow	**G [kg/h]**	3751,20	5126,64	
medium density	**ρ1 [kg/m³]**	786,000	785,00	
absolute temp. (inlet side)	**T1 [K]**	81,60	81,50	
spec. volume at p2 and t1	**V2 [m³/kg]**	0,12	0,12	
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,08	0,08	

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	supercritical	supercritical	
flash (%)			
Kv_flash			
Kv_liquid	2,17	2,97	
Kv_tot	2,17	2,97	
travel (%) (first give Kvs-value!)	60,91	68,98	
selected Kvs-value	**Kvs= 10,00**		
valve type	globe valve		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

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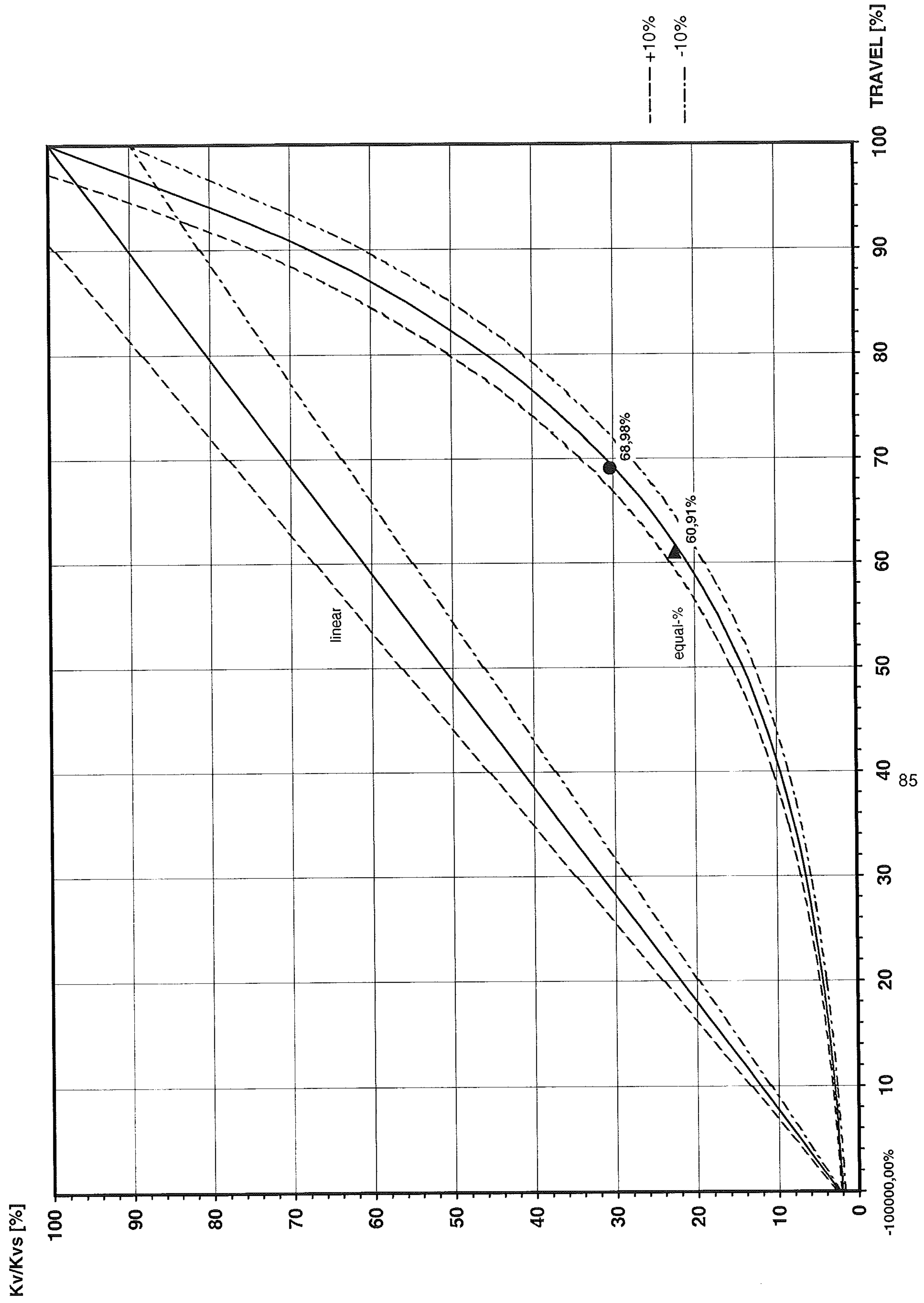
Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FV23013** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FV23073**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1}\sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

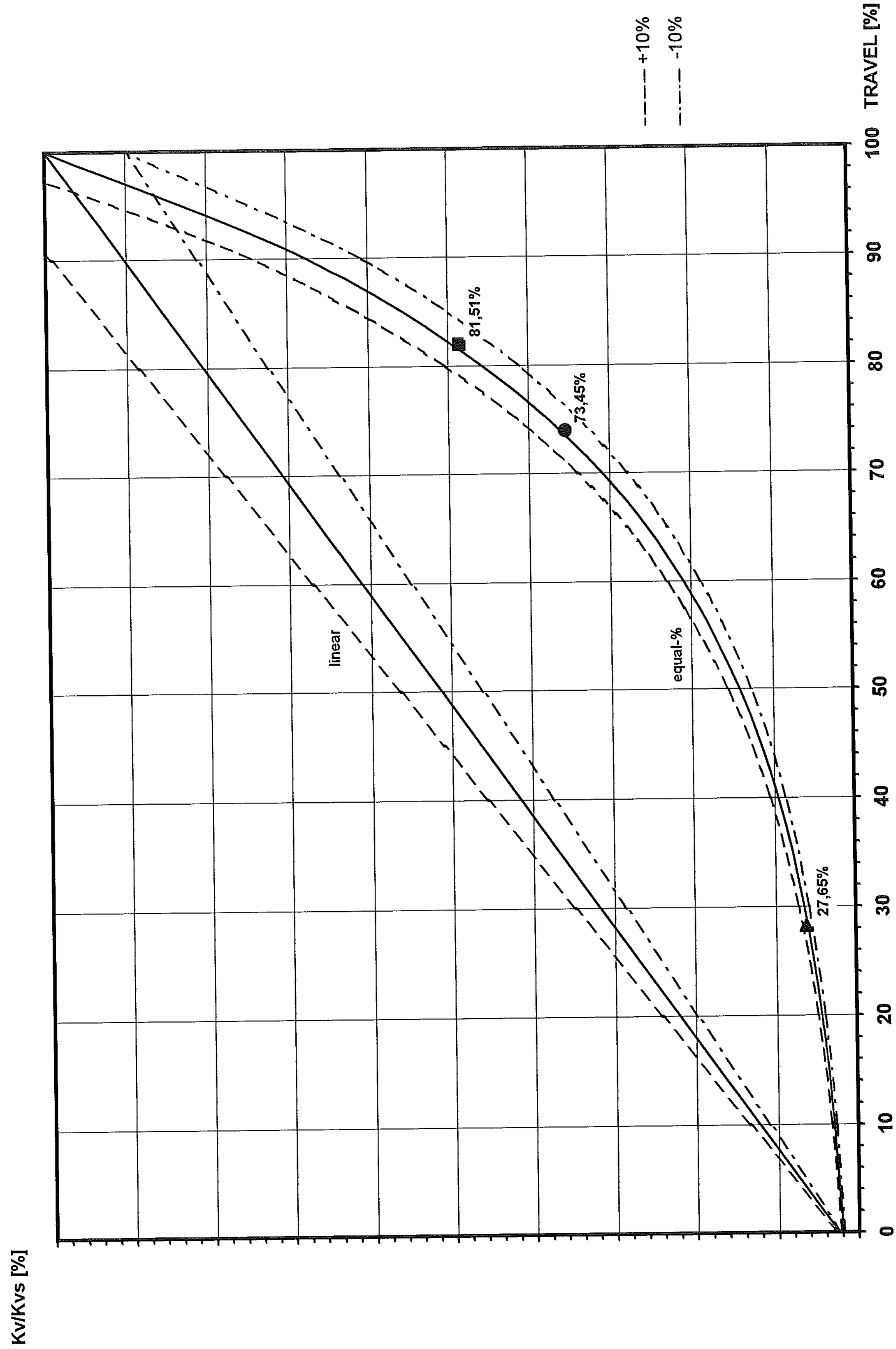
		SERVICE CONDITIONS		
medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
		case 1	case 2	case 3
volume flow	Q [m³/h]	0,80	4,78	6,53
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	500,00	3000,00	4100,00
charge pressure (abs.)	p1 [bar]	5,905	5,90	5,88
discharge pressure (abs.)	p2 [bar]	2,300	2,30	2,30
pressure loss	Δp [bar]	3,605	3,60	3,58
mass flow	G [kg/h]	625,20	3751,20	5126,64
medium density	ρ [kg/m³]	785,000	785,00	785,00
absolute temp. (inlet side)	T1 [K]	81,60	81,60	81,60
spec. volume at p2 and t1	V2 [m³/kg]	0,11	0,11	0,11
spec. volume at p1/2 and t1	V* [m³/kg]	0,08	0,08	0,08
		RESULTS		
		case 1	case 2	case 3
pressure gradient		supercritical	supercritical	supercritical
flash (%)				
Kv_flash				
Kv_liquid		0,37	2,23	3,06
Kv_tot		0,37	2,23	3,06
travel (%) (first give Kvs-value!)		27,65	73,45	81,51
selected Kvs-value		**Kvs=**	**6,30**	
valve type		**globe valve**		

STANDARD DENSITIES OF COMMON GASES		
gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FV23073** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

FV23073_calc

SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **LV23076** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
volume flow	**Q [m³/h]**	0,64	3,85	5,13
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	500,00	3000,00	4000,00
charge pressure (abs.)	**p1 [bar]**	29,000	29,00	29,00
discharge pressure (abs.)	**p2 [bar]**	2,800	2,80	2,80
pressure loss	**Δp [bar]**	26,200	26,20	26,20
mass flow	**G [kg/h]**	714,50	4287,00	5716,00
medium density	**ρ1 [kg/m³]**	1114,000	1114,00	1115,00
absolute temp. (inlet side)	**T1 [K]**	95,60	95,60	95,50
spec. volume at p2 and t1	**V2 [m³/kg]**	0,09	0,09	0,09
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,02	0,02	0,02

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	0,13	0,79	1,06
Kv_tot	0,13	0,79	1,06
travel (%) (first give Kvs-value!)	24,86	70,67	78,01
selected Kvs-value	**Kvs=**	**2,50**	
valve type	globe valve		

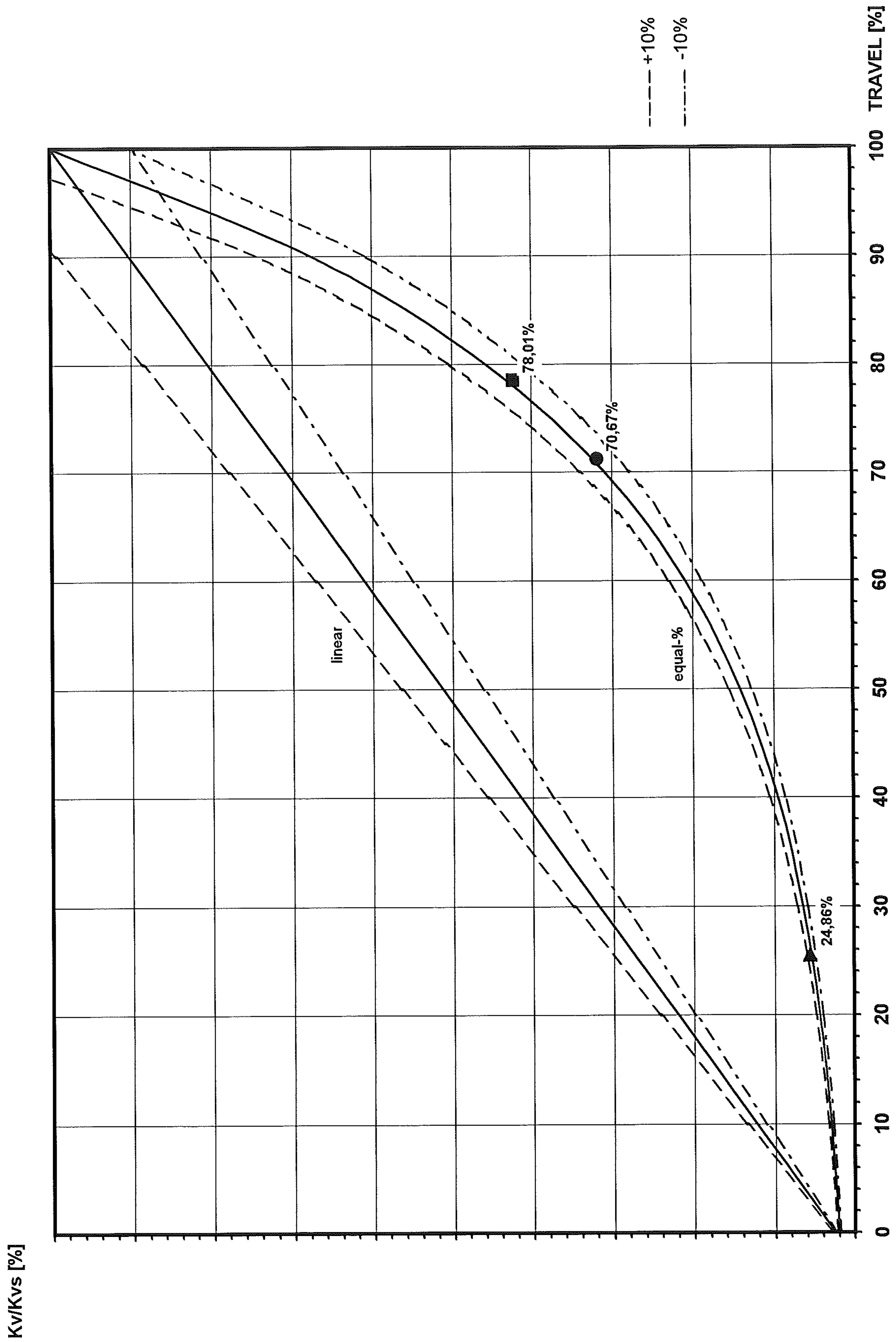
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV23076** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **PK40003** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1}\sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		oxigen		
state		gaseous		
standard density		1,4290 kg/m³		
volume flow	Q [m³/h]	6366,41	5687,28	4645,44
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	26820,00	23760,00	19440,00
charge pressure (abs.)	p1 [bar]	1,35	1,34	1,34
discharge pressure (abs.)	p2 [bar]	1,33	1,32	1,32
pressure loss	Δp [bar]	0,02	0,02	0,02
mass flow	G [kg/h]	38325,78	33953,04	27779,76
medium density	$\rho 1$ [kg/m³]	6,02	5,97	5,98
absolute temp. (inlet side)	T1 [K]	92,50	92,40	92,40
spec. volume at p2 and t1	V2 [m³/kg]	0,18	0,18	0,18
spec. volume at p1/2 and t1	V* [m³/kg]	0,36	0,36	0,36

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	3678,25	3269,14	2674,75
travel (%) (first give Kvs-value!)	66,39	63,37	58,24
selected Kvs-value	Kvs= 13700,00		
valve type	butterfly valve		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Required Valve Size:
DN 500

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	02.11.2004	Möller		Initial Version					

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV40005** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		argon		
state		gaseous		
standard density		1,7840 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	Q [m³/h]	0,19		
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	150,00		
charge pressure (abs.)	p1 [bar]	1,150		
discharge pressure (abs.)	p2 [bar]	1,013		
pressure loss	Δp [bar]	0,137		
mass flow	G [kg/h]	267,60		
medium density	ρ1 [kg/m³]	1386,000		
absolute temp. (inlet side)	T1 [K]	88,30		
spec. volume at p2 and t1	V2 [m³/kg]	0,18		
spec. volume at p1/2 and t1	V* [m³/kg]	0,32		

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	subcritical		
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	9,83		
travel (%) (first give Kvs-value!)	99,57		
selected Kvs-value	**Kvs=**	**10,00**	
valve type	globe valve		

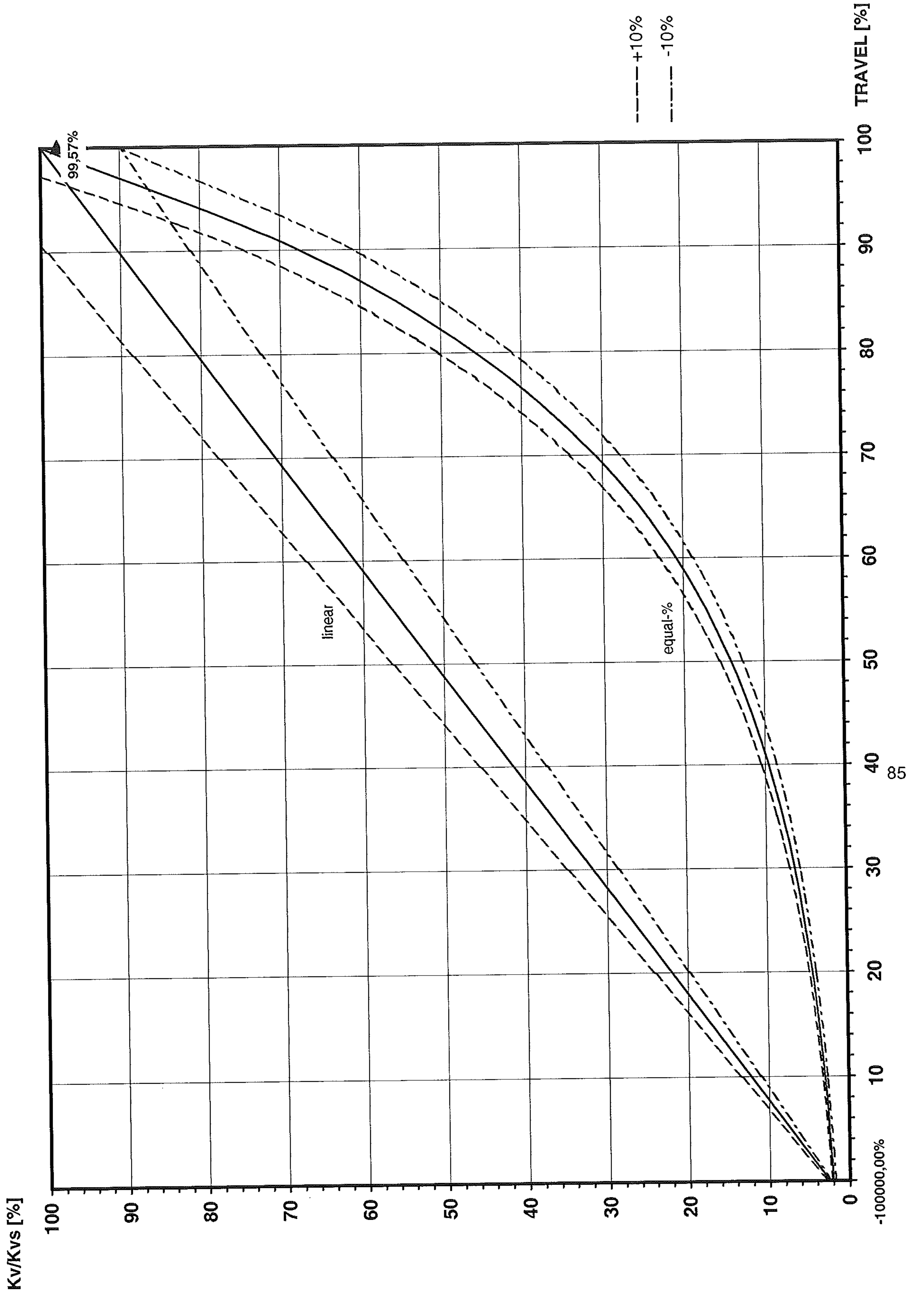
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV40005** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT40007** Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: CAR CONDENSER VESSEL	

SERVICE CLOX

Temperature	$T =$ -187,4	°C
Service Density	$\rho_M =$ 985	kg/m³

GAS ABOVE LIQUID CGOX

Temperature	$T =$ -187,4	°C
Pressure (abs.)	$P =$ 1,38	bar
Gas Density	$\rho_G =$ 5,98	kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES CGOX

Ambient Temperature	$T_U =$ 15	°C
Filling Density	$\rho_F =$ 1,7	kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1)	a =	mm
Distance between L+ and L- Nozzle (see fig. 2)	e = 6370	mm
From L+ Nozzle to 0% Level H1	b = 0	mm
From L+ Nozzle to 100% Level H2	d = 6370	mm
From H1 to H2	c = 6370	mm

CALCULATION ACCORDING TO

○ **Fig. 1**

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{b}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{a}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{d}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{a}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

Diff. Press. 0%	$P_{H1} =$		**mbar**
Diff. Press. 100%	$P_{H2} =$		**mbar**
Span	$P_{H2-H1} =$		**mbar**

◉ **Fig. 2**

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{b}{mm} + \frac{\rho_G}{kg/m^3} \cdot \frac{(e-b)}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{e}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3} \cdot \frac{d}{mm} + \frac{\rho_G}{kg/m^3} \cdot \frac{(e-d)}{mm} - \frac{\rho_F}{kg/m^3} \cdot \frac{e}{mm} \right) \cdot 9{,}81 \cdot 10^{-5} mbar$$

Diff. Press. 0%	$P_{H1} =$	**2,674**	**mbar**
Diff. Press. 100%	$P_{H2} =$	**614,251**	**mbar**
Span	$P_{H2-H1} =$	**611,578**	**mbar**

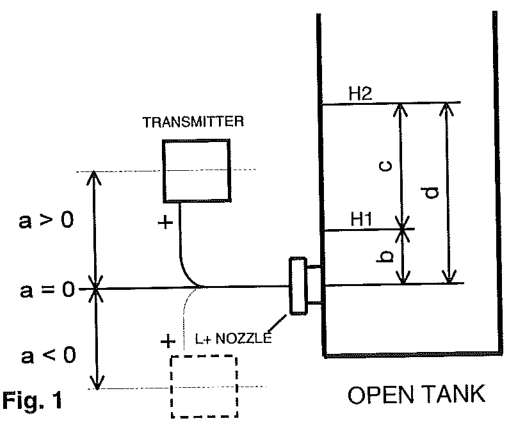


Fig. 1

OPEN TANK

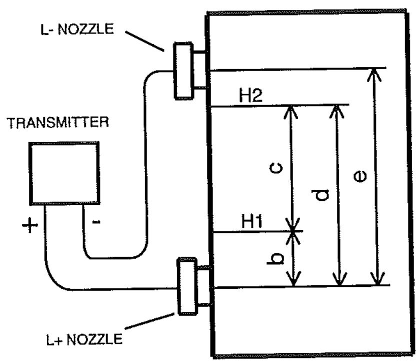


Fig. 2

CLOSED TANK

REMARKS

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.03.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT40017** Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: CAR CONDENSER VESSEL	

SERVICE CLOX

Temperature	T =	-187,4 °C
Service Density	ρ_M =	985 kg/m³

GAS ABOVE LIQUID CGOX

Temperature	T =	-187,4 °C
Pressure (abs.)	P =	1,38 bar
Gas Density	ρ_G =	5,98 kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES CGOX

Ambient Temperature	T_U =	15 °C
Filling Density	ρ_F =	1,7 kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1)	a =	mm
Distance between L+ and L- Nozzle (see fig. 2)	e =	1472 mm
From L+ Nozzle to 0% Level H1	b =	0 mm
From L+ Nozzle to 100% Level H2	d =	1472 mm
From H1 to H2	c =	1472 mm

CALCULATION ACCORDING TO

○ Fig. 1

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

Diff. Press. 0%	P_{H1} =		mbar
Diff. Press. 100%	P_{H2} =		mbar
Span	P_{H2-H1} =		mbar

◉ Fig. 2

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm} + \frac{\rho_G}{kg/m^3}\cdot\frac{(e-b)}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm} + \frac{\rho_G}{kg/m^3}\cdot\frac{(e-d)}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

Diff. Press. 0%	P_{H1} =	0,618	mbar
Diff. Press. 100%	P_{H2} =	141,943	mbar
Span	P_{H2-H1} =	141,325	mbar

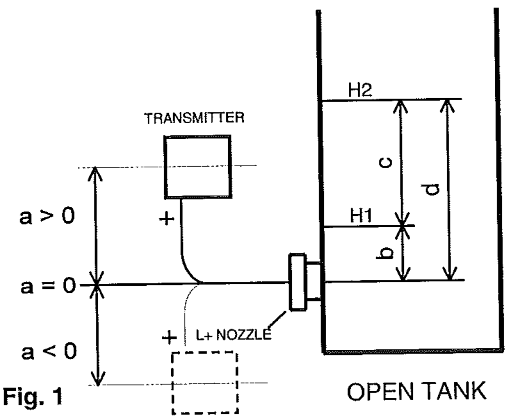


Fig. 1 OPEN TANK

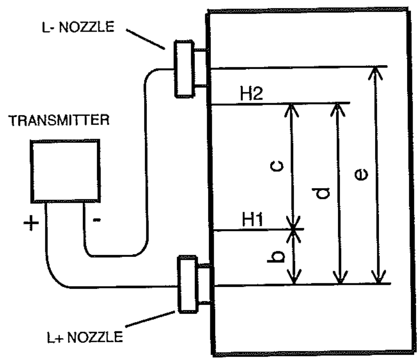


Fig. 2 CLOSED TANK

REMARKS

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.03.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

Project: **ASU No. 9 KOSICE**

TAG - No.: **LV40007**

Project-No.: K70101

Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	8,45	14,44	16,33
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	5812,00	9950,00	11222,00
charge pressure (abs.)	**p1 [bar]**	1,852	1,86	1,85
discharge pressure (abs.)	**p2 [bar]**	1,370	0,90	0,89
pressure loss	**Δp [bar]**	0,482	0,97	0,96
mass flow	**G [kg/h]**	8305,35	14218,55	16036,24
medium density	**ρ1 [kg/m³]**	983,000	985,00	982,00
absolute temp. (inlet side)	**T1 [K]**	85,80	85,60	85,40
spec. volume at p2 and t1	**V2 [m³/kg]**	0,16	0,25	0,25
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,24	0,24	0,24

	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	12,06	14,57	16,49
Kv_tot	12,06	14,57	16,49
travel (%) (first give Kvs-value!)	57,75	62,58	65,73
selected Kvs-value	**Kvs=**	**63,00**	
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

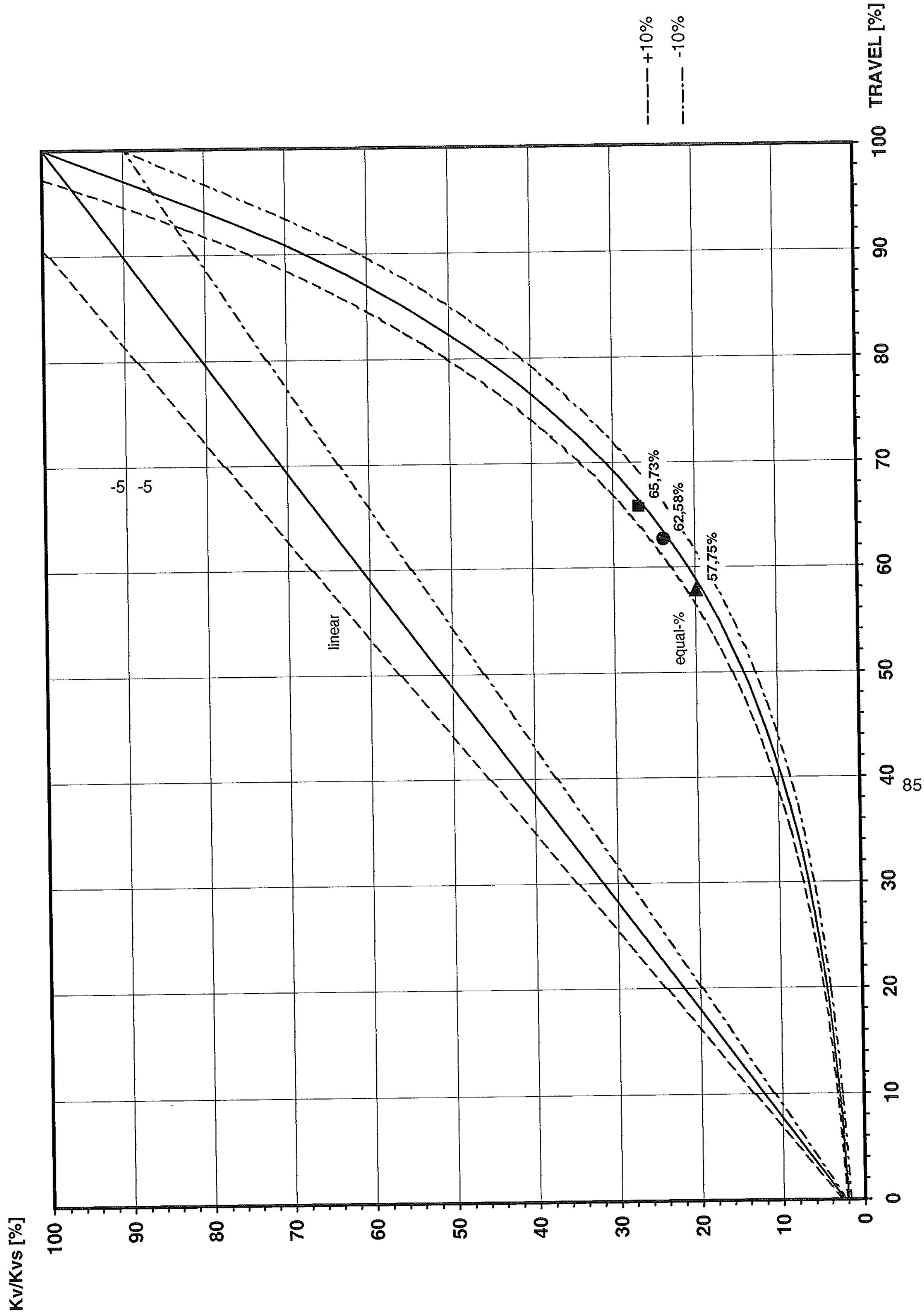
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

85

0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV40007** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **FV40011**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		argon		
state		liquid		
standard density		1,7840 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	Q [m³/h]	25,66	31,34	35,37
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	19932,00	24346,00	27479,00
charge pressure (abs.)	p1 [bar]	1,354	1,35	1,35
discharge pressure (abs.)	p2 [bar]	1,150	1,15	1,15
pressure loss	Δp [bar]	0,204	0,20	0,20
mass flow	G [kg/h]	35558,69	43433,26	49022,54
medium density	ρ1 [kg/m³]	1386,000	1386,00	1386,00
absolute temp. (inlet side)	T1 [K]	88,30	88,30	88,30
spec. volume at p2 and t1	V2 [m³/kg]	0,16	0,16	0,16
spec. volume at p1/2 and t1	V* [m³/kg]	0,27	0,27	0,27

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	66,88	81,69	92,20
Kv_tot	66,88	81,69	92,20
travel (%) (first give Kvs-value!)	66,30	71,41	74,50
selected Kvs-value	**Kvs=**	**250,00**	
valve type	**globe valve**		

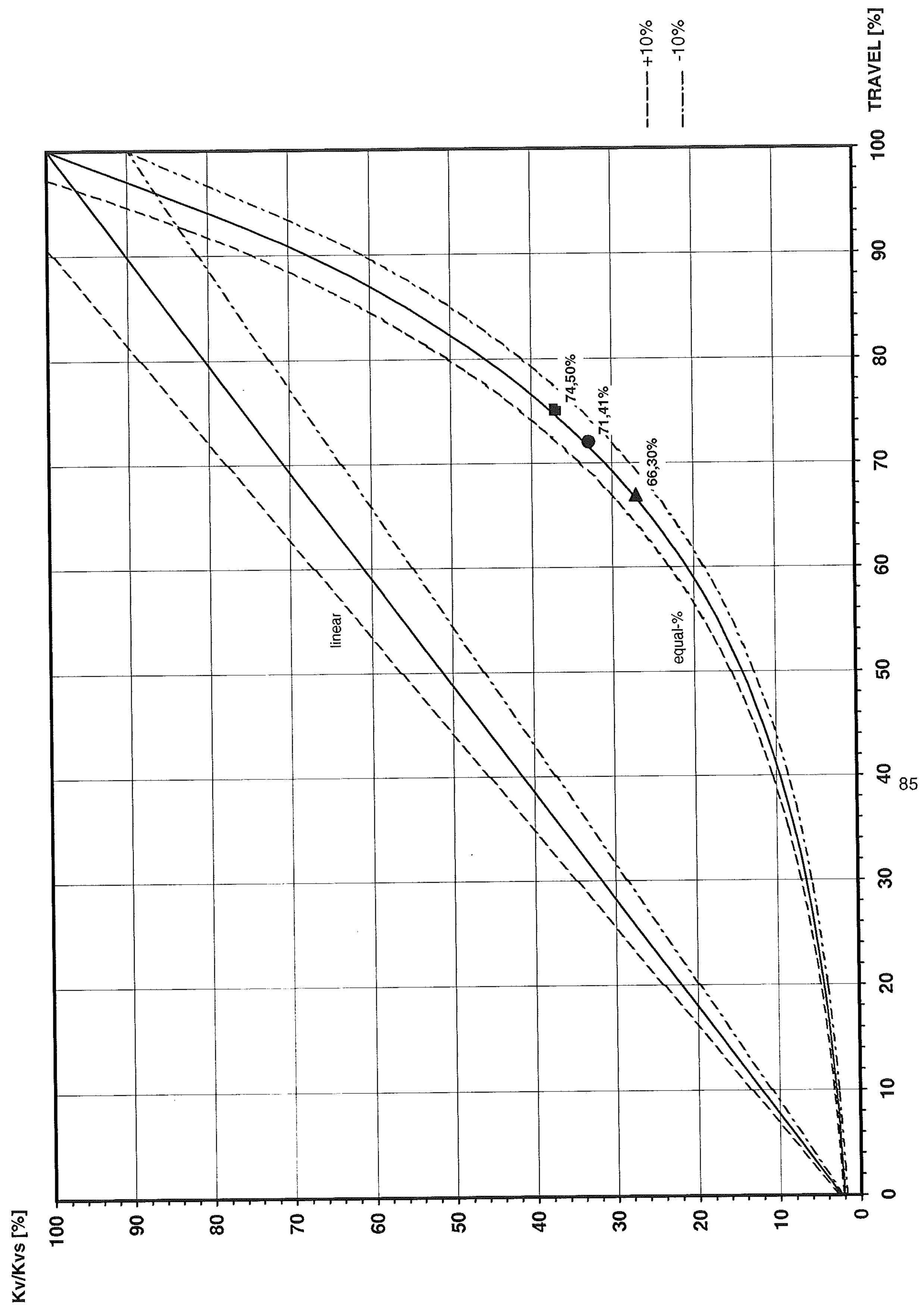
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **FV40011** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HK40012** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids: flow (m³/h)	liquids: flow (kg/h)	gases: flow (m³/h)	gases: flow (kg/h)	steam: flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^*\sqrt{\frac{\rho 1}{1000^*\Delta p}}$	$k_v = \frac{G}{\sqrt{1000^*\rho 1^*\Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^*T1}{\Delta p^*p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^*\Delta p^*p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257p1}\sqrt{\rho_N{}^*T1}$	$k_v = \frac{G}{257p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		argon		
state		gaseous		
standard density		1,7840 kg/m³		
volume flow	**Q [m³/h]**	411,69	823,38	2470,15
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	1500,00	3000,00	9000,00
charge pressure (abs.)	**p1 [bar]**	1,15	1,15	1,15
discharge pressure (abs.)	**p2 [bar]**	1,01	1,01	1,01
pressure loss	**Δp [bar]**	0,137	0,14	0,14
mass flow	**G [kg/h]**	2676,00	5352,00	16056,00
medium density	**ρ1 [kg/m³]**	6,50	6,50	6,50
absolute temp. (inlet side)	**T1 [K]**	88,30	88,30	88,30
spec. volume at p2 and t1	**V2 [m³/kg]**	0,18	0,18	0,18
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,32	0,32	0,32

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	98,32	196,64	589,92
travel (%) (first give Kvs-value!)	50,23	67,95	96,03
selected Kvs-value	**Kvs=**	**689,00**	
valve type	**butterfly valve**		

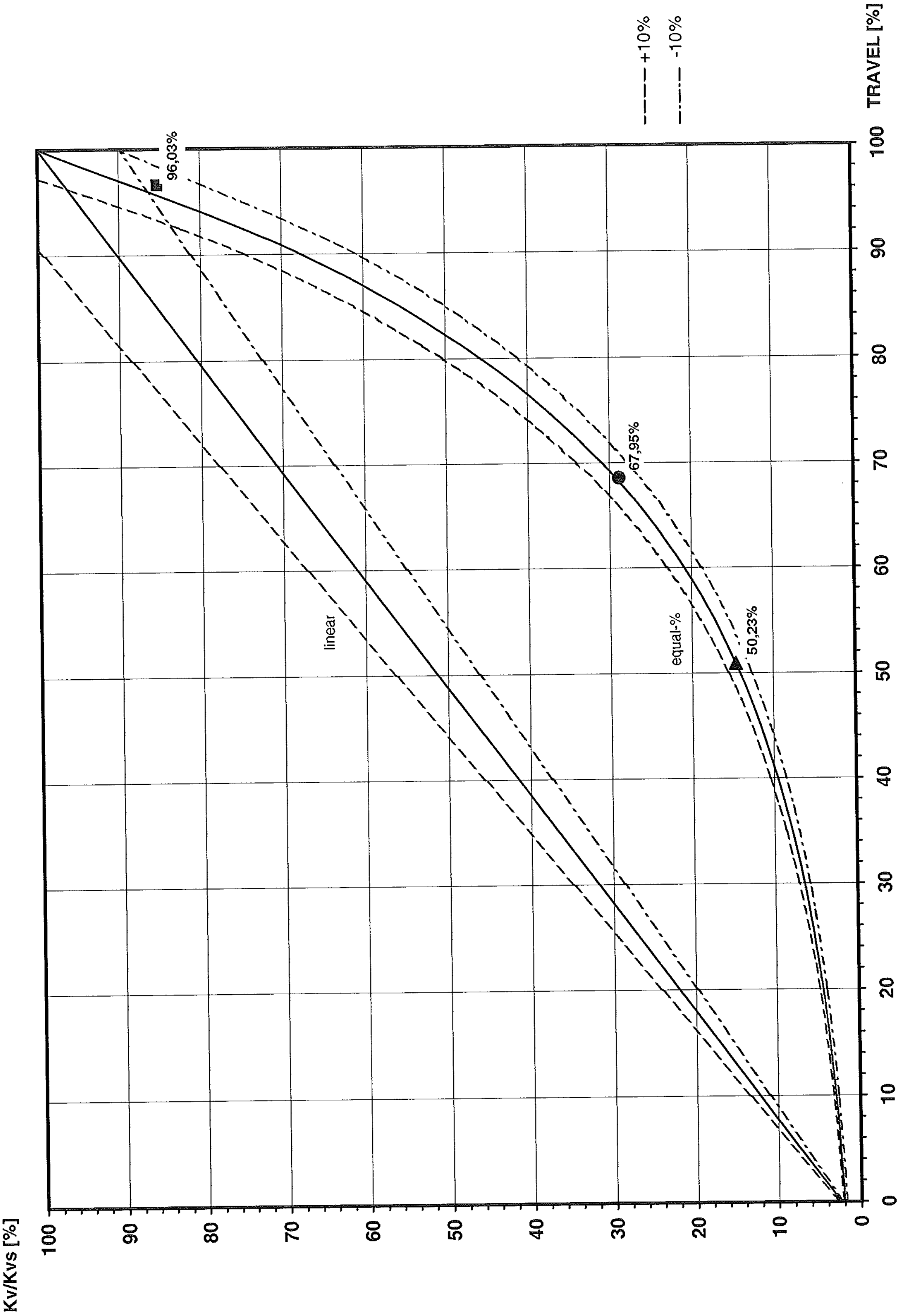
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HK40012** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

Project: ASU No. 9 KOSICE

TAG - No.: HV40014

Project-No.: K70101

Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		argon		
state		liquid		
standard density		1,7840 kg/m³		
volume flow	Q [m³/h]	0,71	0,85	0,96
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	550,00	660,00	745,00
charge pressure (abs.)	p1 [bar]	2,034	2,03	2,03
discharge pressure (abs.)	p2 [bar]	1,500	1,50	1,50
pressure loss	Δp [bar]	0,534	0,53	0,53
mass flow	G [kg/h]	981,20	1177,44	1329,08
medium density	ρ1 [kg/m³]	1386,000	1386,00	1386,00
absolute temp. (inlet side)	T1 [K]	88,30	88,30	88,30
spec. volume at p2 and t1	V2 [m³/kg]	0,12	0,12	0,12
spec. volume at p1/2 and t1	V* [m³/kg]	0,18	0,18	0,18

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	1,14	1,37	1,55
Kv_tot	1,14	1,37	1,55
travel (%) (first give Kvs-value!)	56,32	60,98	64,08
selected Kvs-value	Kvs= 6,30		
valve type	globe valve		

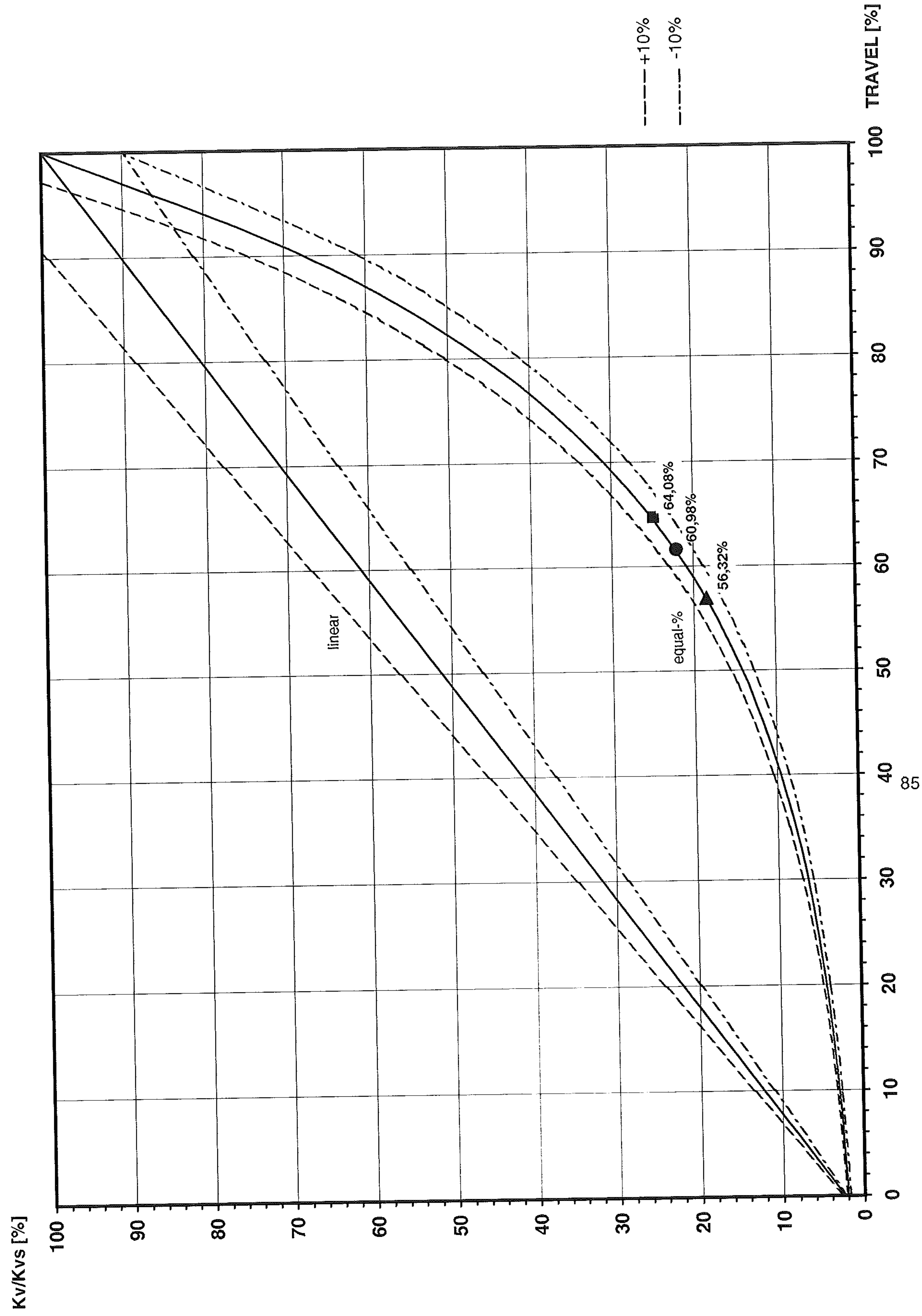
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV40014** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT40053** Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: SUMP CAR COLUMN 1	

SERVICE LOX

Temperature	T =	-181,3 °C
Service Density	ρ_M =	1154 kg/m³

GAS ABOVE LIQUID GOX

Temperature	T =	-180 °C
Pressure (abs.)	P =	1,25 bar
Gas Density	ρ_G =	5,5 kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES GOX

Ambient Temperature	T_U =	15 °C
Filling Density	ρ_F =	1,7 kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1)	a =	mm
Distance between L+ and L- Nozzle (see fig. 2)	e =	2791 mm
From L+ Nozzle to 0% Level H1	b =	0 mm
From L+ Nozzle to 100% Level H2	d =	2791 mm
From H1 to H2	c =	2791 mm

CALCULATION ACCORDING TO

○ Fig. 1

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

Diff. Press. 0%	P_{H1} =		mbar
Diff. Press. 100%	P_{H2} =		mbar
Span	P_{H2-H1} =		mbar

◉ Fig. 2

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm} + \frac{\rho_G}{kg/m^3}\cdot\frac{(e-b)}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm} + \frac{\rho_G}{kg/m^3}\cdot\frac{(e-d)}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}\,mbar$$

Diff. Press. 0%	P_{H1} =	1,040	mbar
Diff. Press. 100%	P_{H2} =	315,389	mbar
Span	P_{H2-H1} =	314,349	mbar

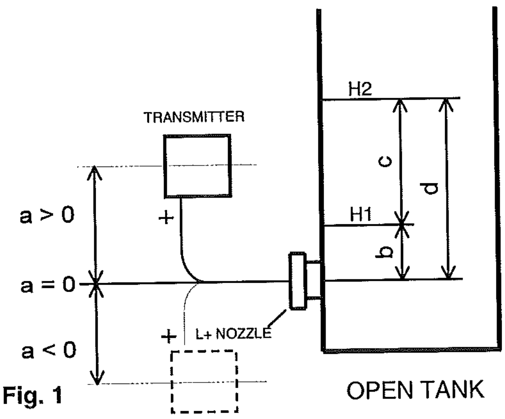


Fig. 1 OPEN TANK

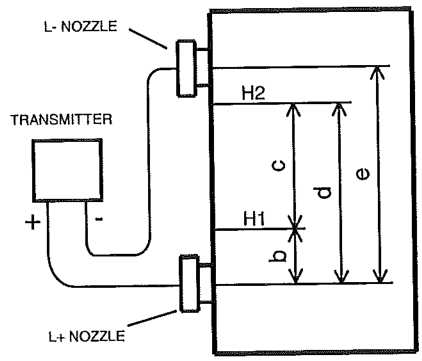


Fig. 2 CLOSED TANK

REMARKS

0	17.03.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

Project: ASU No. 9 KOSICE

TAG - No.: HV40110

Project-No.: K70101

Page: of:

RECYCLE LOX PUMP 1

calculation of Kv-value	pressure gradient	liquids: flow (m³/h)	liquids: flow (kg/h)	gases: flow (m³/h)	gases: flow (kg/h)	steam: flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
volume flow	Q [m³/h]	23,40	28,68	32,32
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	18900,00	23100,00	26075,00
charge pressure (abs.)	p1 [bar]	1,377	1,40	1,40
discharge pressure (abs.)	p2 [bar]	1,357	1,38	1,38
pressure loss	Δp [bar]	0,020	0,02	0,02
mass flow	G [kg/h]	27008,10	33009,90	37261,18
medium density	$\rho 1$ [kg/m³]	1154,000	1151,00	1153,00
absolute temp. (inlet side)	T1 [K]	92,00	92,20	92,20
spec. volume at p2 and t1	V2 [m³/kg]	0,18	0,17	0,17
spec. volume at p1/2 and t1	V* [m³/kg]	0,35	0,34	0,34

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	177,78	218,73	245,12
Kv_tot	177,78	218,73	245,12
travel (%) (first give Kvs-value!)	83,43	88,72	91,64
selected Kvs-value	Kvs= 340,00		
valve type	globe valve		

STANDARD DENSITIES OF COMMON GASES

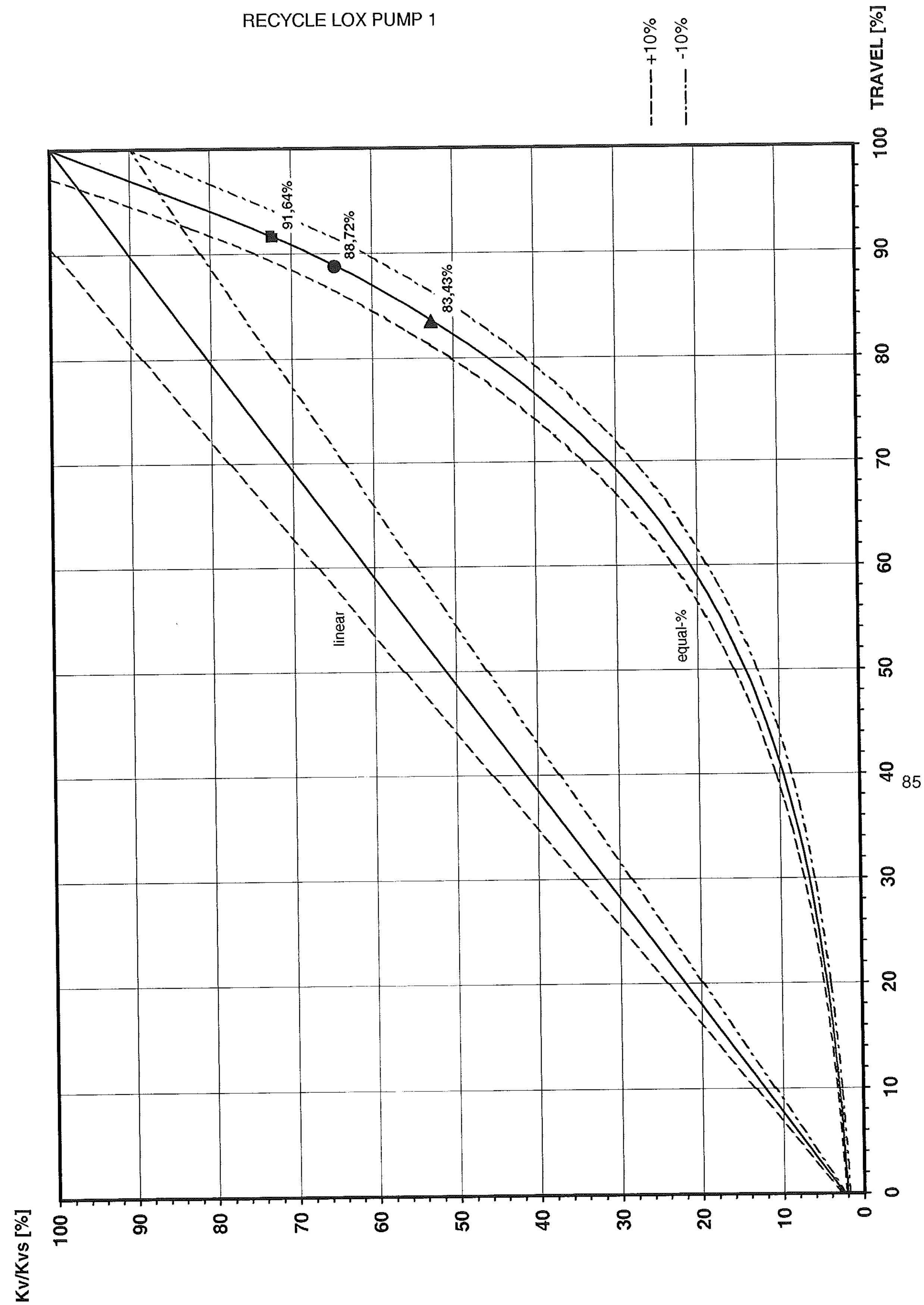
gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV40110** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:

RECYCLE LOX PUMP 1



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

TAG - No.:	**PV40170**
Project-No.:	K70101
Page:	of:

Project: **ASU No. 9 KOSICE**

RECYCLE LOX PUMP 1

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	23,40	28,68	32,32
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	18900,00	23100,00	26075,00
charge pressure (abs.)	**p1 [bar]**	8,000	8,00	8,00
discharge pressure (abs.)	**p2 [bar]**	1,513	1,53	1,53
pressure loss	**Δp [bar]**	6,487	6,47	6,47
mass flow	**G [kg/h]**	27008,10	33009,90	37261,18
medium density	**ρ1 [kg/m³]**	1154,000	1151,00	1153,00
absolute temp. (inlet side)	**T1 [K]**	92,00	92,20	92,20
spec. volume at p2 and t1	**V2 [m³/kg]**	0,16	0,16	0,16
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,06	0,06	0,06

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	9,87	12,10	13,65
Kv_tot	9,87	12,10	13,65
travel (%) (first give Kvs-value!)	64,23	69,43	72,51
selected Kvs-value	**Kvs=**	**40,00**	
valve type	globe valve		

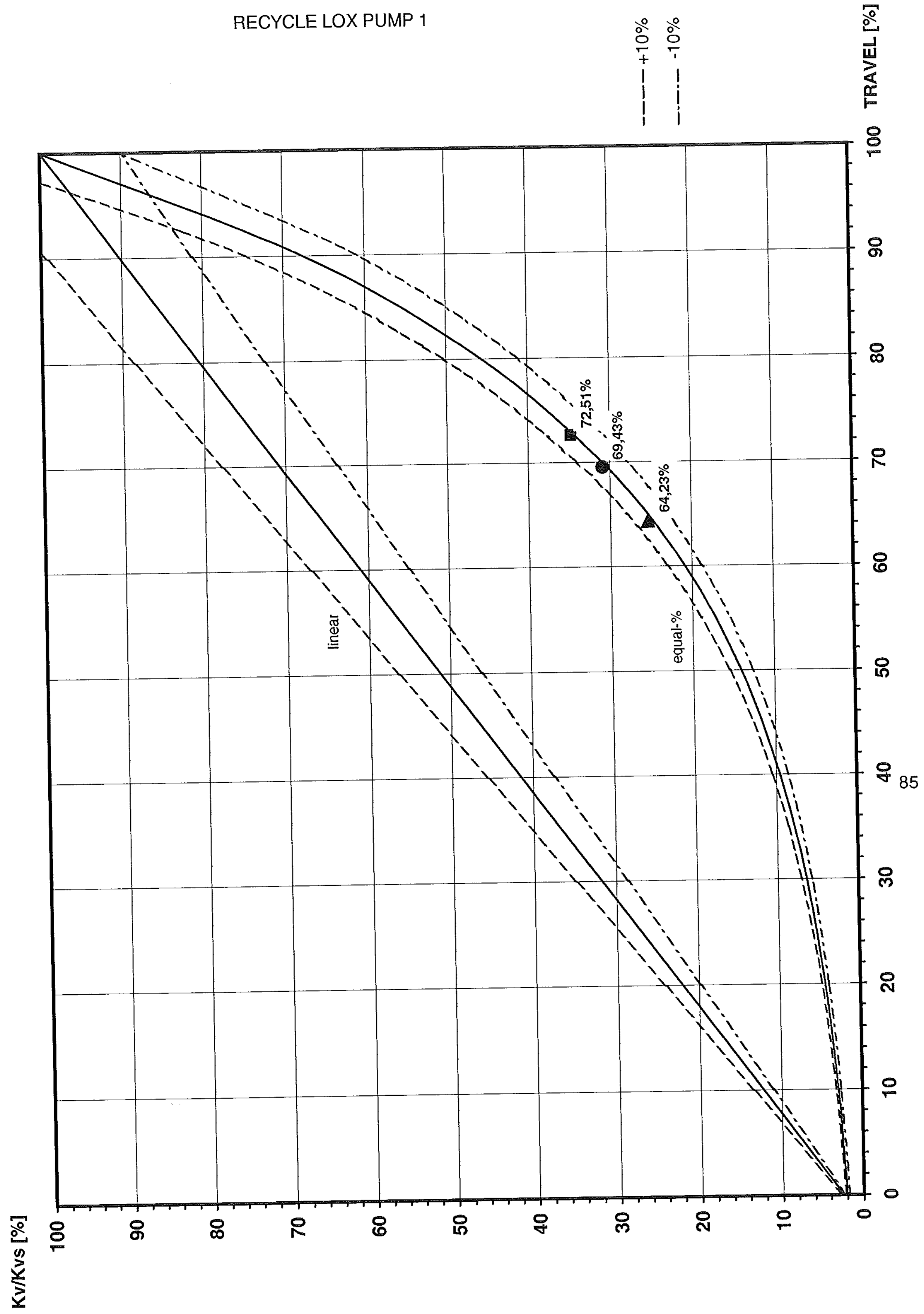
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	Specification Control Valve Characteristic	TAG - No.: **PV40170** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

SPEZ80DE.XLS 25.08.1997

PV40170_calc.XLS

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **PV43021**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^*\sqrt{\frac{\rho 1}{1000^*\Delta p}}$	$K_v = \frac{G}{\sqrt{1000^*\rho 1^*\Delta p}}$	$K_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^*T1}{\Delta p^*p2}}$	$K_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^*\Delta p^*p2}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257p1}\sqrt{\rho_N{}^*T1}$	$K_v = \frac{G}{257p1}\sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	0,83	1,01	1,14
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	594,00	726,00	820,00
charge pressure (abs.)	**p1 [bar]**	3,989	4,06	4,10
discharge pressure (abs.)	**p2 [bar]**	2,641	2,64	2,64
pressure loss	**Δp [bar]**	1,348	1,42	1,46
mass flow	**G [kg/h]**	742,74	907,79	1025,33
medium density	**ρ1 [kg/m³]**	720,000	719,00	718,00
absolute temp. (inlet side)	**T1 [K]**	94,50	94,70	94,80
spec. volume at p2 and t1	**V2 [m³/kg]**	0,11	0,11	0,11
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,14	0,14	0,14

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)	20,00	20,00	20,00
Kv_flash	1,33	1,59	1,77
Kv_liquid	0,60	0,72	0,80
Kv_tot	1,93	2,31	2,57
travel (%) (first give Kvs-value!)	69,82	74,31	77,07
selected Kvs-value	**Kvs= 6,30**		
valve type	**globe valve**		

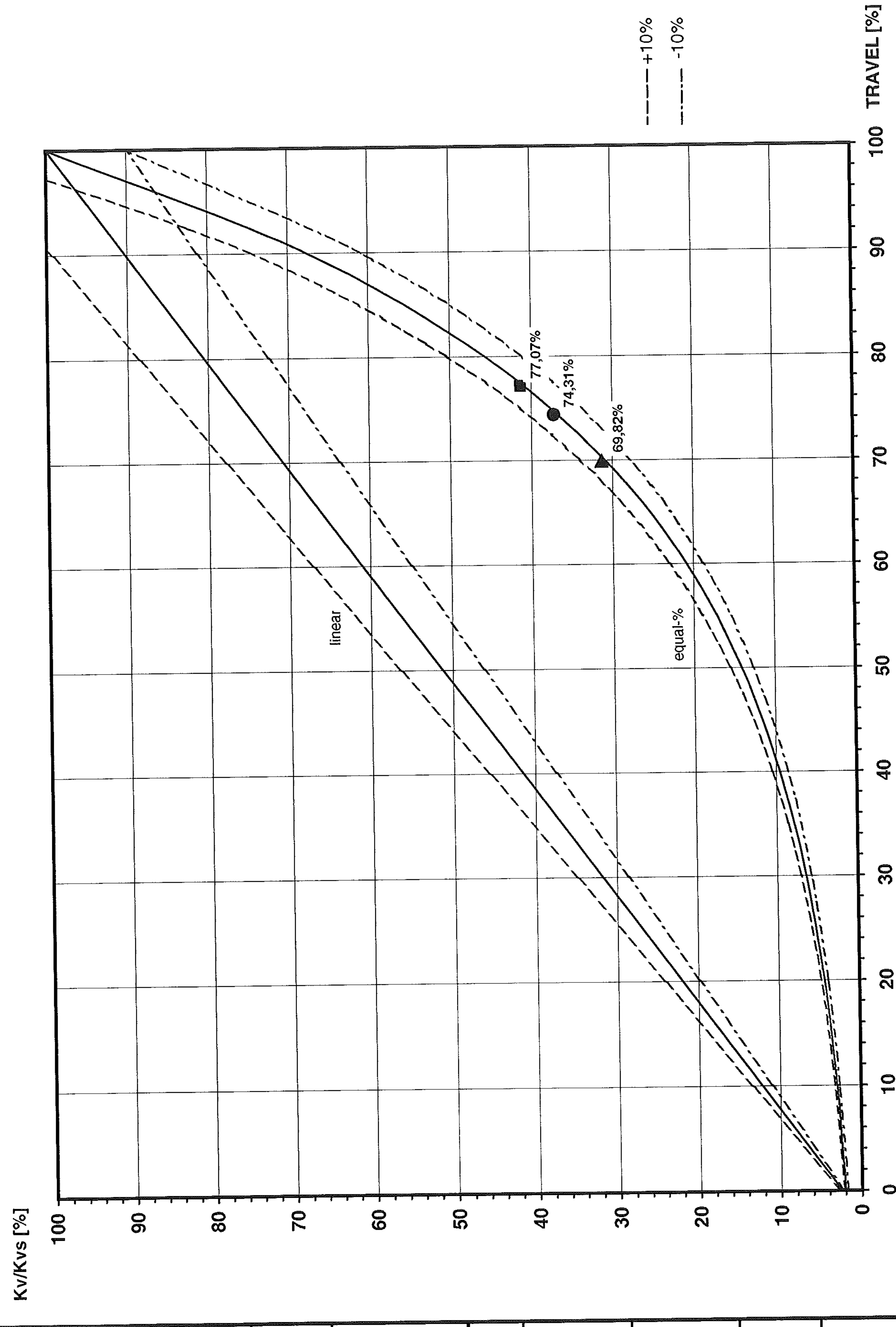
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **PV43021** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

PV43021_calc.XLS

AIR LIQUIDE	Specification Calculation of Control (Butterfly-)Valves	TAG - No.: PV43022 Project-No.: K70101
Air Liquide AGS GmbH	Project: ASU No. 9 KOSICE	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m^3/h)	liquids flow (kg/h)	gases flow (m^3/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000 * \Delta p}}$	$K_v = \frac{G}{\sqrt{1000 * \rho 1 * \Delta p}}$	$K_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N * T1}{\Delta p * p2}}$	$K_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N * \Delta p * p2}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1}\sqrt{\rho_N * T1}$	$K_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		argon		
state		gaseous		
standard density		1,7840 kg/m³		
		case 1	case 2	case 3
volume flow	Q [m³/h]	0,44	0,43	0,43
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	2,00	2,00	2,00
charge pressure (abs.)	p1 [bar]	1,500	1,50	1,50
discharge pressure (abs.)	p2 [bar]	1,013	1,01	1,01
pressure loss	Δp [bar]	0,487	0,49	0,49
mass flow	G [kg/h]	3,57	3,57	3,57
medium density	$\rho 1$ [kg/m³]	8,170	8,22	8,27
absolute temp. (inlet side)	T1 [K]	90,50	90,70	90,90
spec. volume at p2 and t1	V2 [m³/kg]	0,19	0,19	0,19
spec. volume at p1/2 and t1	V* [m³/kg]	0,25	0,25	0,25

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	0,07	0,07	0,07
travel (%) (first give Kvs-value!)	43,98	44,00	44,03
selected Kvs-value	Kvs=	0,63	
valve type	globe valve		

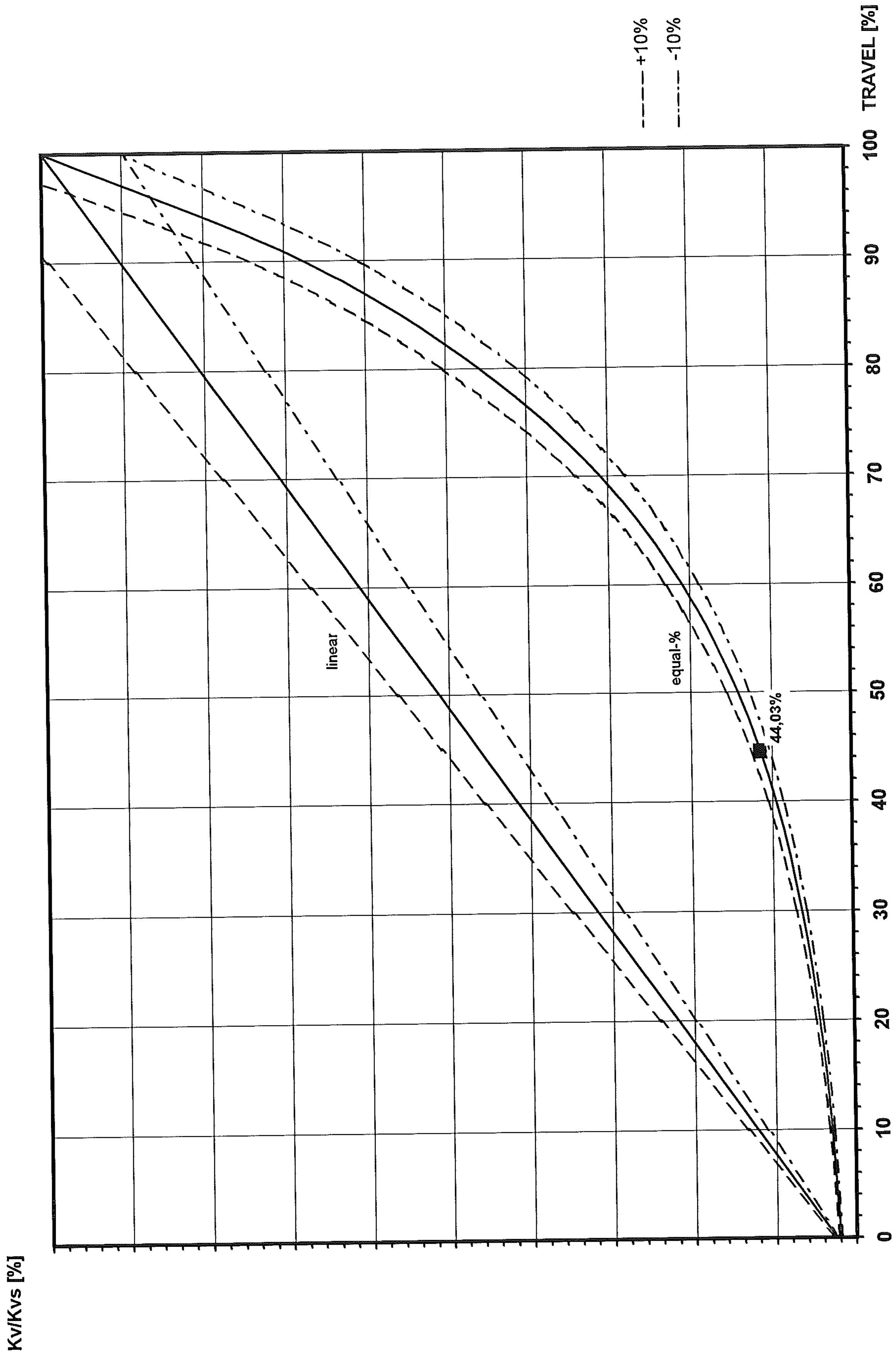
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **PV43022** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

PV43022_calc

SPEZ80DE.XLS 26.08.1997

AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT43023**
		Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: PURE ARGON COLUMN	

SERVICE ARGON

Temperature T = **-180,4** °C
Service Density ρ_M = **1360** kg/m³

GAS ABOVE LIQUID ARGON

Temperature T = **-180,4** °C
Pressure (abs.) P = **1,74** bar
Gas Density ρ_G = **9,5** kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES ARGON

Ambient Temperature T_U = **15** °C
Filling Density ρ_F = **2,9** kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1) a = mm
Distance between L+ and L- Nozzle (see fig. 2) e = **2500** mm

From L+ Nozzle to 0% Level H1 b = **0** mm
From L+ Nozzle to 100% Level H2 d = **2500** mm
From H1 to H2 c = **2500** mm

CALCULATION ACCORDING TO

○ **Fig. 1**

$$P_{H1}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}mbar$$

$$P_{H2}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5}mbar$$

Diff. Press. 0% **P_{H1} =** **mbar**

Diff. Press. 100% **P_{H2} =** **mbar**

Span **P_{H2-H1} =** **mbar**

◉ **Fig. 2**

$$P_{H1}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm}+\frac{\rho_G}{kg/m^3}\cdot\frac{(e-b)}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}mbar$$

$$P_{H2}=\left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm}+\frac{\rho_G}{kg/m^3}\cdot\frac{(e-d)}{mm}-\frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5}mbar$$

Diff. Press. 0% **P_{H1} =** **1,618** **mbar**

Diff. Press. 100% **P_{H2} =** **332,715** **mbar**

Span **P_{H2-H1} =** **331,097** **mbar**

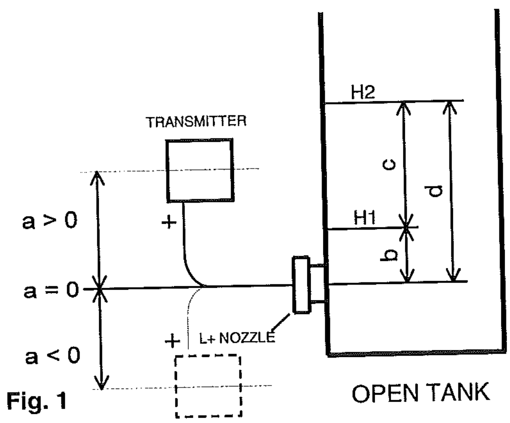


Fig. 1 OPEN TANK

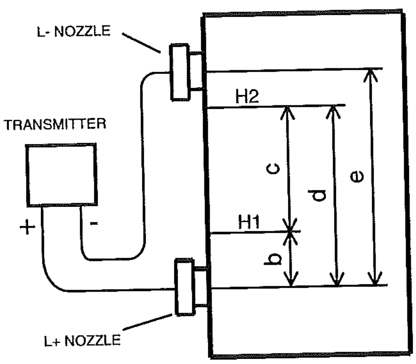


Fig. 2 CLOSED TANK

REMARKS

0	17.03.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

SPEZ82DE.XLS 09.09.1997

LT43023_calc.xls

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **LV43023** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		argon		
state		liquid		
standard density		1,7840 kg/m³		
volume flow	**Q [m³/h]**	0,71	0,86	0,97
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	538,00	658,00	743,00
charge pressure (abs.)	**p1 [bar]**	5,502	5,50	5,50
discharge pressure (abs.)	**p2 [bar]**	3,341	3,34	3,34
pressure loss	**Δp [bar]**	2,161	2,16	2,16
mass flow	**G [kg/h]**	959,79	1173,87	1325,51
medium density	**ρ1 [kg/m³]**	1360,000	1360,00	1360,00
absolute temp. (inlet side)	**T1 [K]**	92,60	92,60	92,60
spec. volume at p2 and t1	**V2 [m³/kg]**	0,06	0,06	0,06
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,07	0,07	0,07

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	0,56	0,68	0,77
Kv_tot	0,56	0,68	0,77
travel (%) (first give Kvs-value!)	61,75	66,89	70,00
selected Kvs-value	**Kvs=**	**2,50**	
valve type	globe valve		

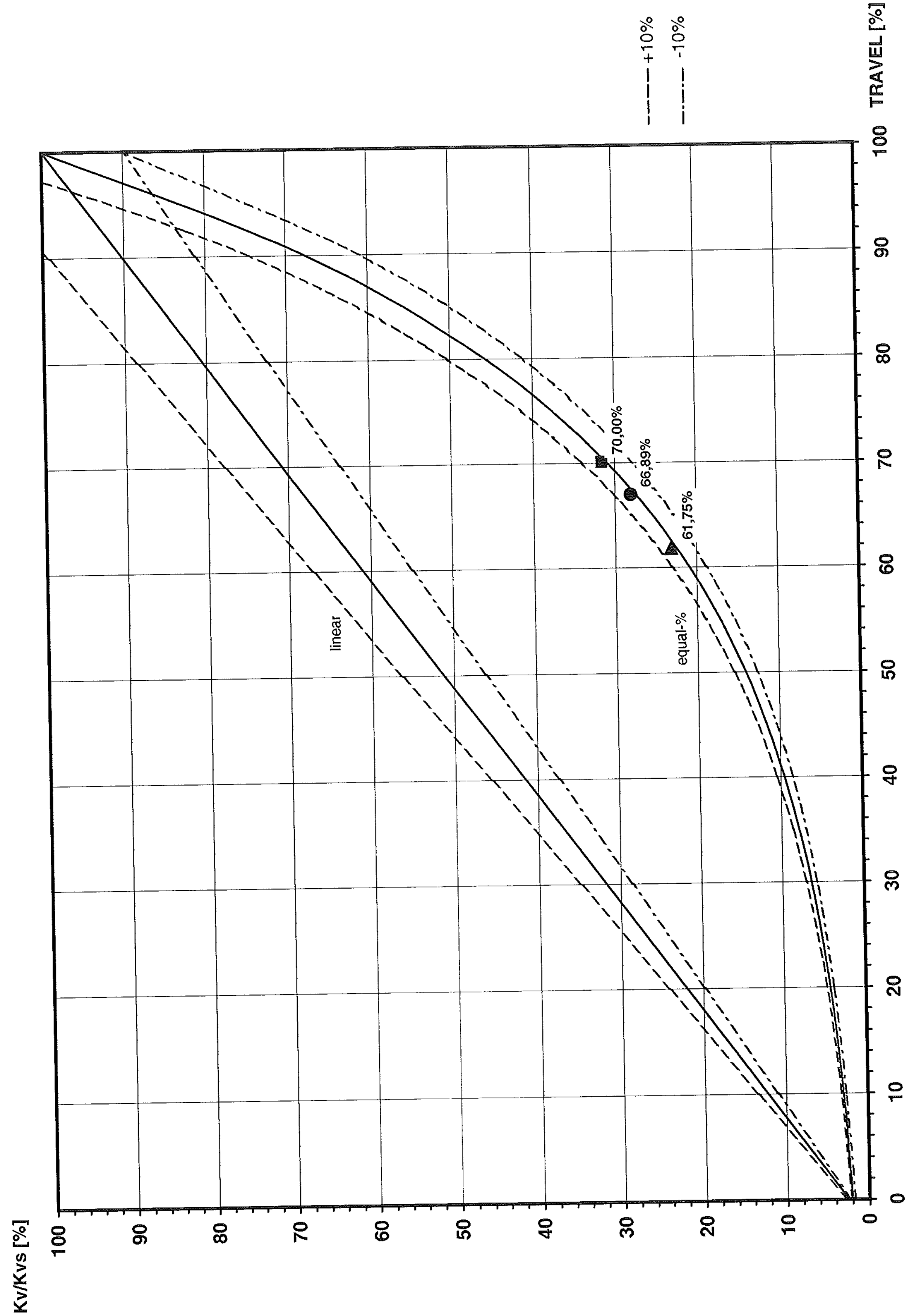
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV43023** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

LV43023_calc.XLS

SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

Project: **ASU No. 9 KOSICE**

TAG - No.: **LV43026**

Project-No.: K70101

Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium	nitrogen		
state	liquid		
standard density	1,2504 kg/m³		
	case 1	**case 2**	**case 3**
volume flow Q [m³/h]	0,83	1,01	1,14
standard flow (0°C, 1,013 bar) Q_N [Nm³/h]	594,00	726,00	820,00
charge pressure (abs.) p1 [bar]	3,989	4,06	4,10
discharge pressure (abs.) p2 [bar]	2,535	2,54	2,54
pressure loss Δp [bar]	1,454	1,53	1,57
mass flow G [kg/h]	742,74	907,79	1025,33
medium density $\rho 1$ [kg/m³]	720,000	719,00	718,00
absolute temp. (inlet side) T1 [K]	94,50	94,70	94,80
spec. volume at p2 and t1 V2 [m³/kg]	0,11	0,11	0,11
spec. volume at p1/2 and t1 V* [m³/kg]	0,14	0,14	0,14

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)	20,00	20,00	20,00
Kv_flash	1,31	1,56	1,74
Kv_liquid	0,58	0,69	0,77
Kv_tot	1,89	2,26	2,52
travel (%) (first give Kvs-value!)	69,21	73,75	76,54
selected Kvs-value	**Kvs= 6,30**		
valve type	globe valve		

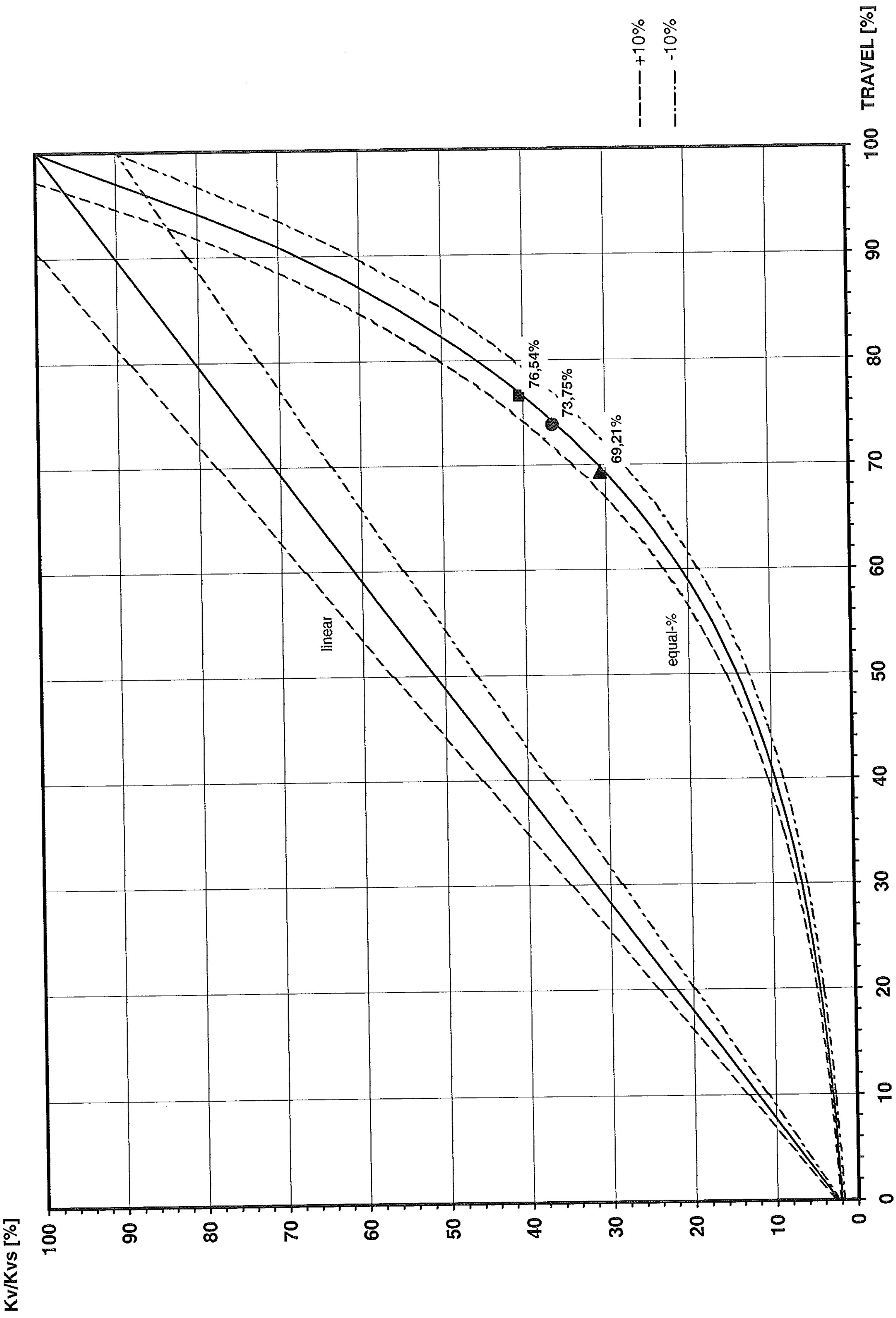
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV43026** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

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AIR LIQUIDE	**Specification** Differential Pressure Calculation	TAG - No.: **LT43027** Project No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:
	Designation: PURE ARGON CONDENSER VESSEL	

SERVICE LIN

Temperature $T =$ **-187** °C
Service Density $\rho_M =$ **764** kg/m³

GAS ABOVE LIQUID GAN

Temperature $T =$ **-187** °C
Pressure (abs.) $P =$ **2,5** bar
Gas Density $\rho_G =$ **10,7** kg/m³

FILLING OF CAPILLARY TUBES/ MEASURING TUBES GAN

Ambient Temperature $T_U =$ **15** °C
Filling Density $\rho_F =$ **2,9** kg/m³

TANK DISTANCES

Distance between L+-Nozzle and Transmitter (see fig. 1) $a =$ mm
Distance between L+ and L- Nozzle (see fig. 2) $e =$ **1804** mm

From L+ Nozzle to 0% Level H1 $b =$ **0** mm
From L+ Nozzle to 100% Level H2 $d =$ **1804** mm
From H1 to H2 $c =$ **1804** mm

CALCULATION ACCORDING TO

○ **Fig. 1**

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{a}{mm}\right)\cdot 9{,}81\cdot 10^{-5} mbar$$

Diff. Press. 0% $P_{H1} =$ mbar

Diff. Press. 100% $P_{H2} =$ mbar

Span $P_{H2-H1} =$ mbar

◉ **Fig. 2**

$$P_{H1} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{b}{mm} + \frac{\rho_G}{kg/m^3}\cdot\frac{(e-b)}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5} mbar$$

$$P_{H2} = \left(\frac{\rho_M}{kg/m^3}\cdot\frac{d}{mm} + \frac{\rho_G}{kg/m^3}\cdot\frac{(e-d)}{mm} - \frac{\rho_F}{kg/m^3}\cdot\frac{e}{mm}\right)\cdot 9{,}81\cdot 10^{-5} mbar$$

Diff. Press. 0% $P_{H1} =$ **1,380** mbar

Diff. Press. 100% $P_{H2} =$ **134,648** mbar

Span $P_{H2-H1} =$ **133,268** mbar

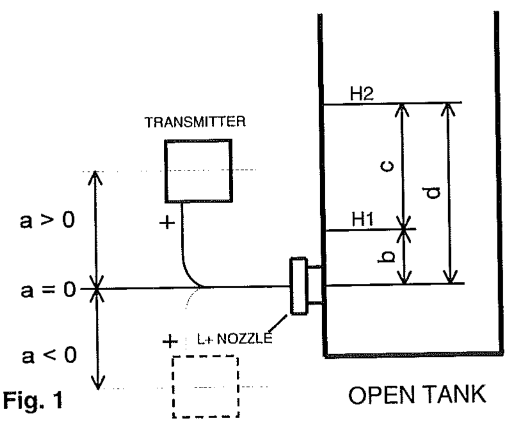


Fig. 1 OPEN TANK

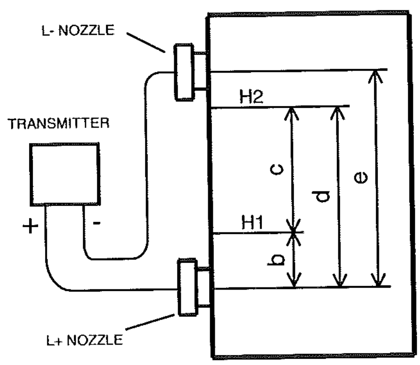


Fig. 2 CLOSED TANK

REMARKS

0	17.03.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **LV43027** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
subcritical	$p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^*\Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
supercritical	$p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^*T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	0,87	1,07	1,21
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	594,00	726,00	820,00
charge pressure (abs.)	**p1 [bar]**	2,759	2,90	2,85
discharge pressure (abs.)	**p2 [bar]**	2,642	2,64	2,64
pressure loss	**Δp [bar]**	0,117	0,25	0,21
mass flow	**G [kg/h]**	742,74	907,79	1025,33
medium density	**ρ1 [kg/m³]**	722,900	718,00	718,60
absolute temp. (inlet side)	**T1 [K]**	93,90	94,80	94,70
spec. volume at p2 and t1	**V2 [m³/kg]**	0,11	0,11	0,11
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,20	0,19	0,20

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)	15,00	15,00	15,00
Kv_flash	3,38	2,81	3,48
Kv_liquid	2,17	1,81	2,23
Kv_tot	5,55	4,62	5,71
travel (%) (first give Kvs-value!)	72,93	68,25	73,66
selected Kvs-value	**Kvs= 16,00**		
valve type	globe valve		

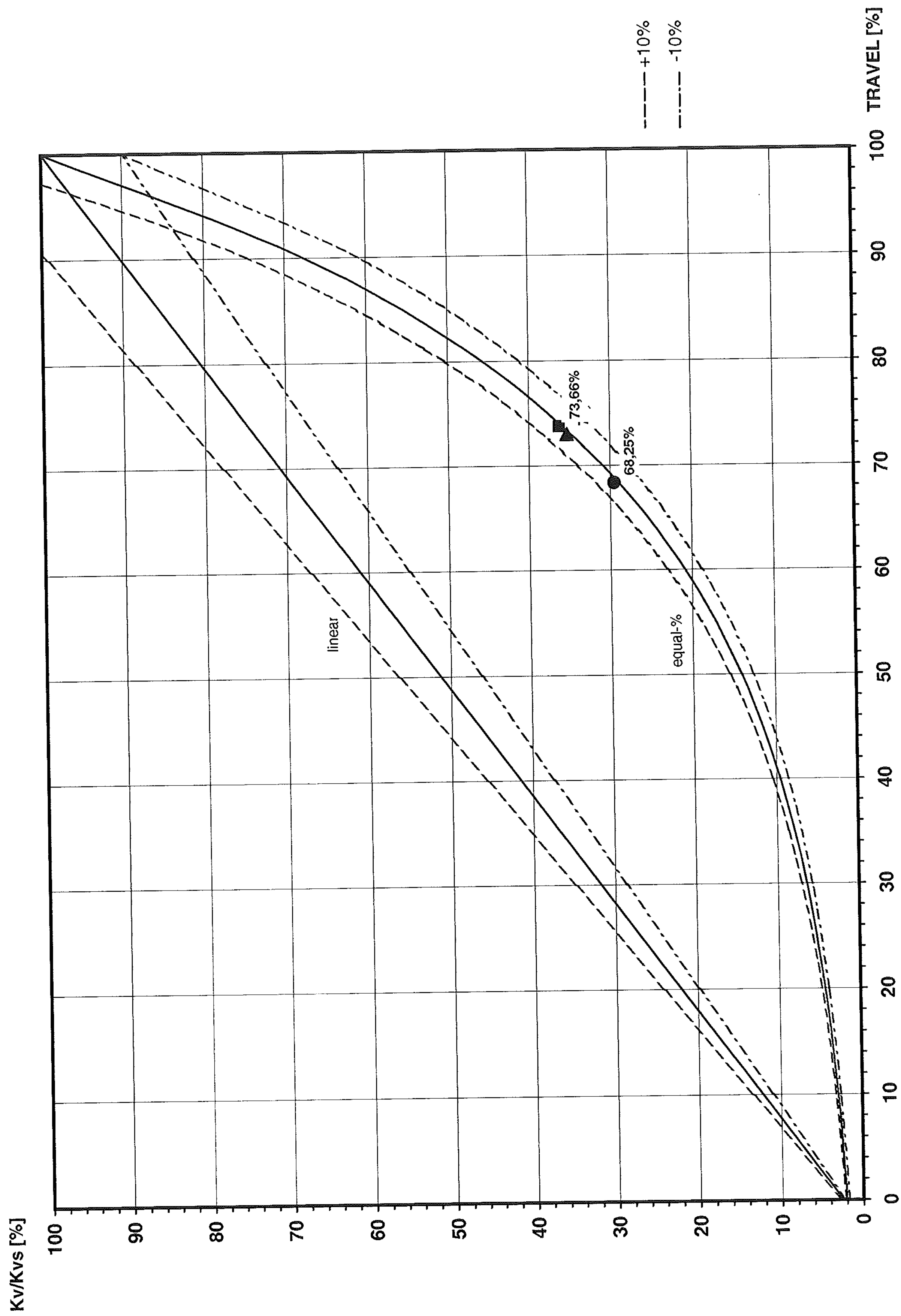
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV43027** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

Project: ASU No. 9 KOSICE

TAG - No.: PV43028

Project-No.: K70101

Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	case 2	case 3
volume flow	Q [m³/h]	68,42	83,71	94,57
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	586,00	717,00	810,00
charge pressure (abs.)	p1 [bar]	2,500	2,50	2,50
discharge pressure (abs.)	p2 [bar]	1,500	1,50	1,50
pressure loss	Δp [bar]	1,000	1,00	1,00
mass flow	G [kg/h]	732,73	896,54	1012,82
medium density	ρ1 [kg/m³]	10,710	10,71	10,71
absolute temp. (inlet side)	T1 [K]	86,00	86,00	86,00
spec. volume at p2 and t1	V2 [m³/kg]	0,17	0,17	0,17
spec. volume at p1/2 and t1	V* [m³/kg]	0,20	0,20	0,20

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	9,65	11,81	13,34
travel (%) (first give Kvs-value!)	63,66	68,82	71,94
selected Kvs-value	Kvs= 40,00		
valve type	globe valve		

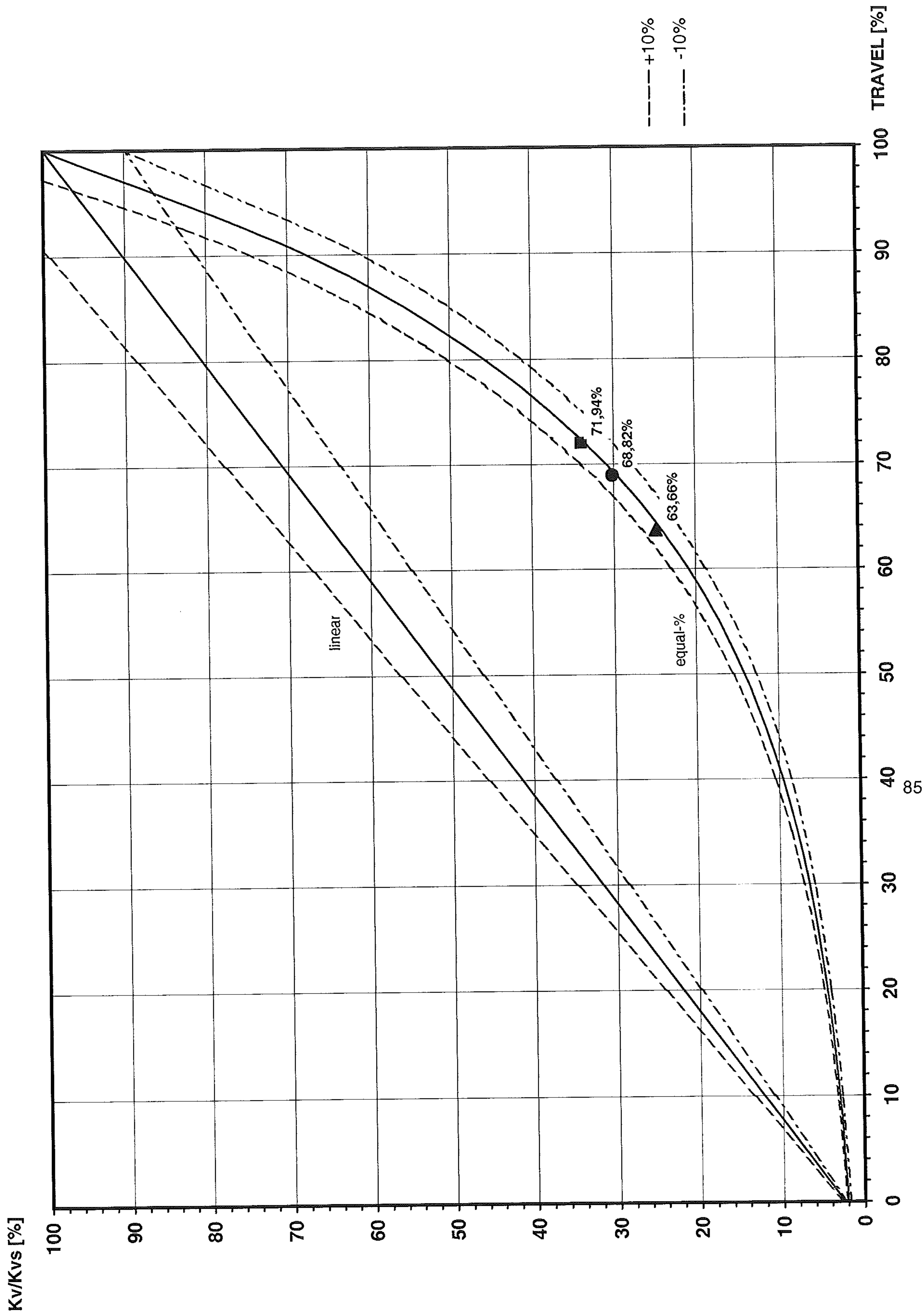
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **PV43028** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE Air Liquide AGS GmbH	**Specification** Calculation of Control (Butterfly-)Valves Project: ASU No. 9 KOSICE	TAG - No.: **LV43033** Project-No.: K70101 Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^*\Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^*T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		argon		
state		liquid		
standard density		1,7840 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	0,71	0,86	0,97
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	538,00	658,00	743,00
charge pressure (abs.)	**p1 [bar]**	5,502	5,50	5,50
discharge pressure (abs.)	**p2 [bar]**	1,740	1,74	1,74
pressure loss	**Δp [bar]**	3,762	3,76	3,76
mass flow	**G [kg/h]**	959,79	1173,87	1325,51
medium density	**ρ1 [kg/m³]**	1360,000	1360,00	1360,00
absolute temp. (inlet side)	**T1 [K]**	92,60	92,60	92,60
spec. volume at p2 and t1	**V2 [m³/kg]**	0,11	0,11	0,11
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,07	0,07	0,07

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	0,42	0,52	0,59
Kv_tot	0,42	0,52	0,59
travel (%) (first give Kvs-value!)	66,07	71,22	74,32
selected Kvs-value	**Kvs=**	**1,60**	
valve type	globe valve		

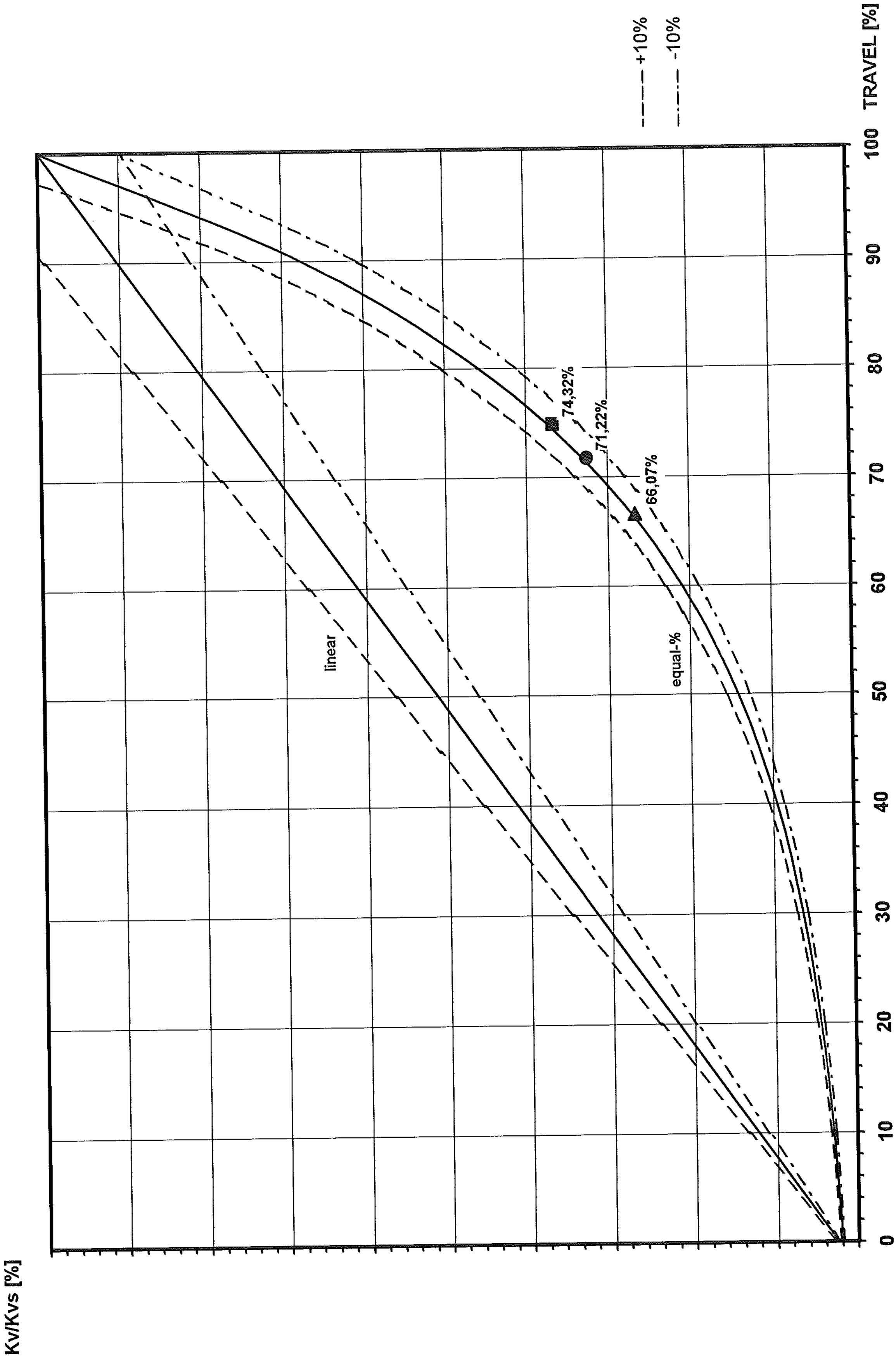
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **LV43033** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

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AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV61110**
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Project-No.: K70101
		Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
volume flow	**Q [m³/h]**	19,00	25,36	31,76
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	15000,00	20000,00	25000,00
charge pressure (abs.)	**p1 [bar]**	3,684	3,70	3,68
discharge pressure (abs.)	**p2 [bar]**	3,634	3,65	3,63
pressure loss	**Δp [bar]**	0,050	0,05	0,05
mass flow	**G [kg/h]**	21435,00	28580,00	35725,00
medium density	**ρ1 [kg/m³]**	1128,000	1127,00	1125,00
absolute temp. (inlet side)	**T1 [K]**	92,90	93,00	92,90
spec. volume at p2 and t1	**V2 [m³/kg]**	0,07	0,07	0,07
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,13	0,13	0,13

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	90,45	120,72	151,22
Kv_tot	90,45	120,72	151,22
travel (%) (first give Kvs-value!)	66,15	73,53	79,29
selected Kvs-value	**Kvs=**	**340,00**	
valve type	**globe valve**		

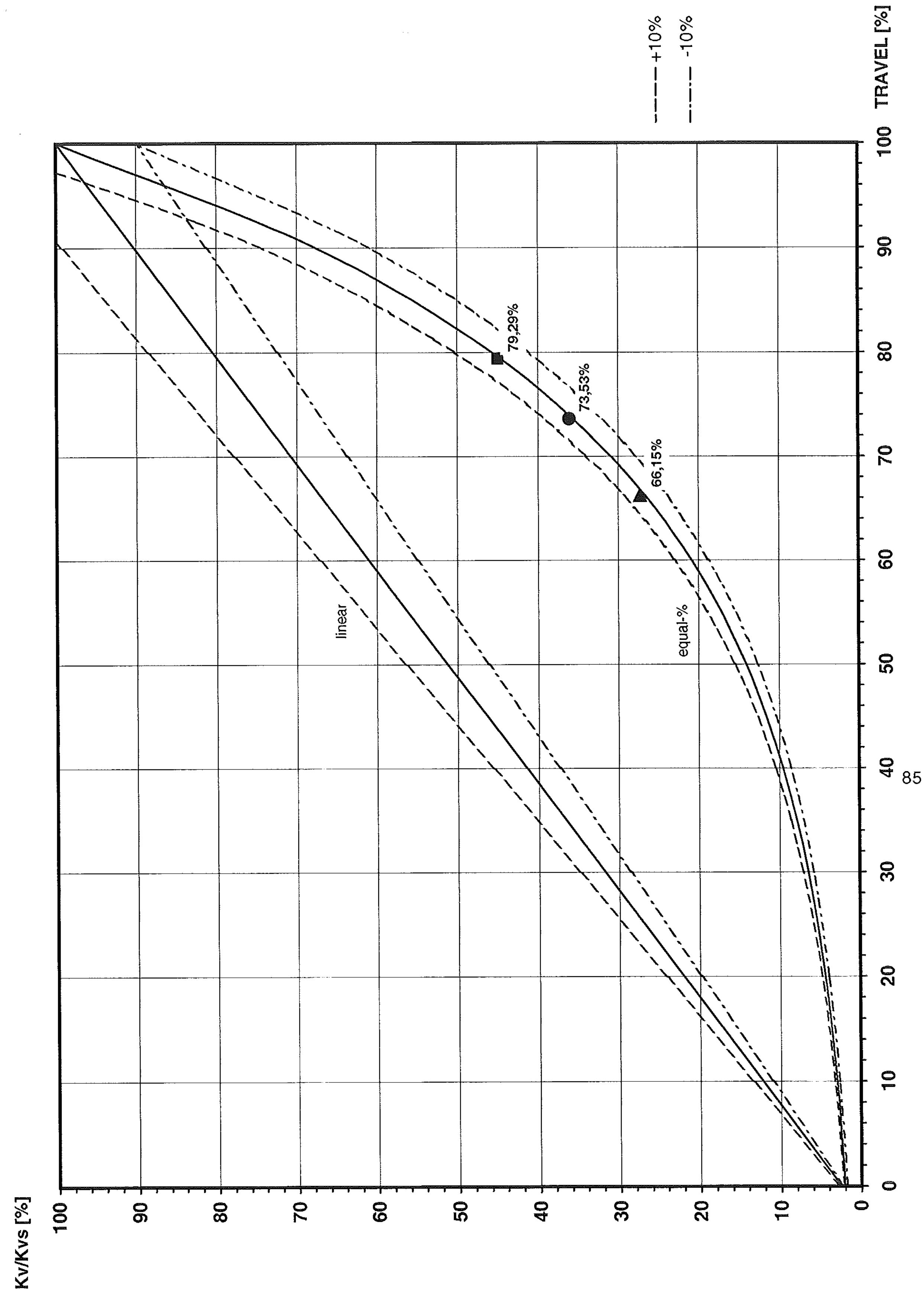
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV61110** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **PV61170** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

RECYCLE LOX PUMP 1

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho_1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho_1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	1,91	25,43	31,76
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	1500,00	20000,00	25000,00
charge pressure (abs.)	**p1 [bar]**	29,000	29,00	29,00
discharge pressure (abs.)	**p2 [bar]**	3,999	4,03	4,01
pressure loss	**Δp [bar]**	25,001	24,97	24,99
mass flow	**G [kg/h]**	2143,50	28580,00	35725,00
medium density	**ρ_1 [kg/m³]**	1125,000	1124,00	1125,00
absolute temp. (inlet side)	**T1 [K]**	94,80	95,00	94,80
spec. volume at p2 and t1	**V2 [m³/kg]**	0,06	0,06	0,06
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,02	0,02	0,02

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	0,40	5,39	6,74
Kv_tot	0,40	5,39	6,74
travel (%) (first give Kvs-value!)	-5,44	60,80	66,48
selected Kvs-value	**Kvs=**	**25,00**	
valve type	**globe valve**		

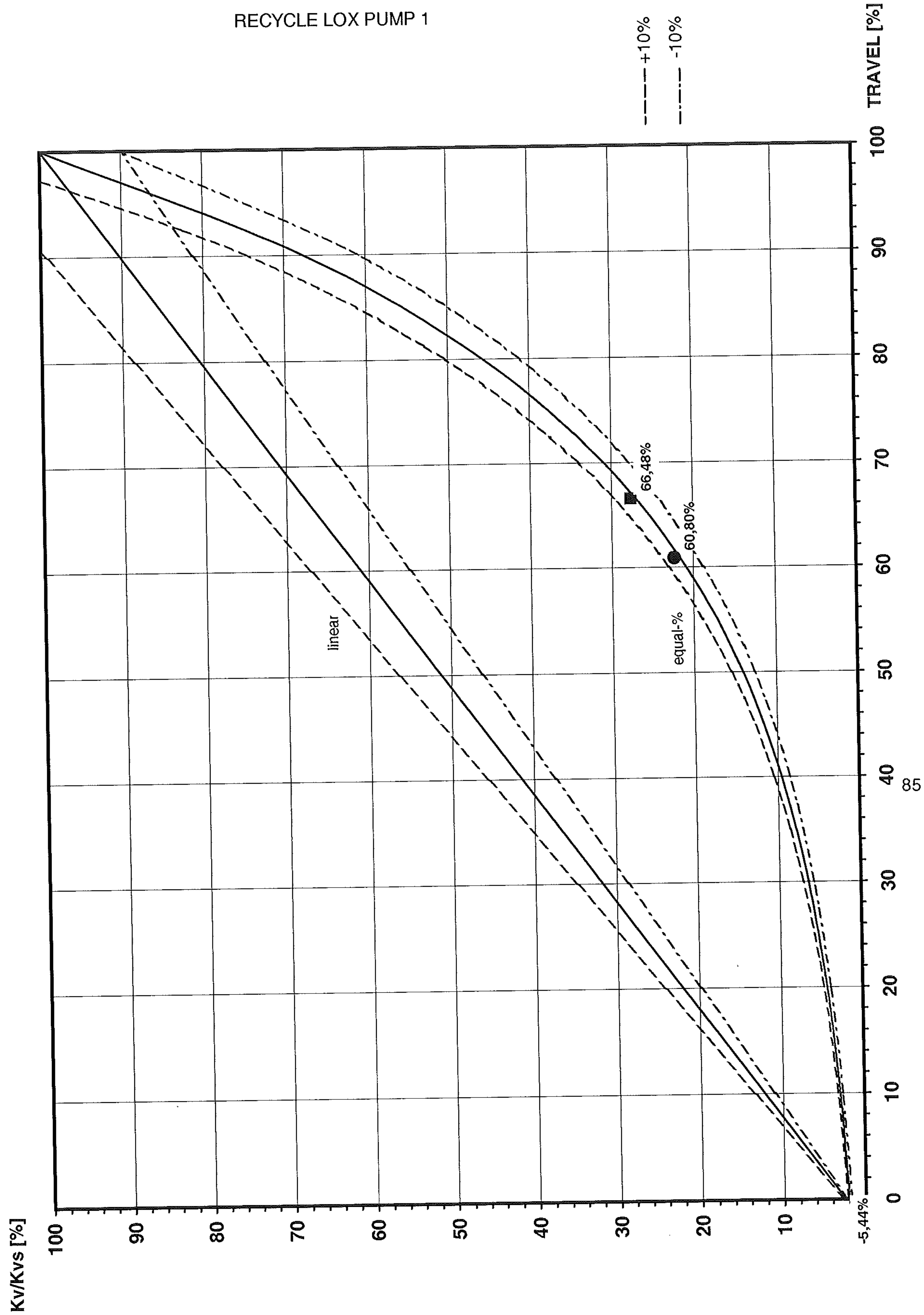
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.:	**PV61170**
		Project No.:	K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page:	of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV61210**
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Project-No.: K70101
		Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
volume flow	**Q [m³/h]**	19,00	25,36	31,76
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	15000,00	20000,00	25000,00
charge pressure (abs.)	**p1 [bar]**	3,684	3,70	3,68
discharge pressure (abs.)	**p2 [bar]**	3,634	3,65	3,63
pressure loss	**Δp [bar]**	0,050	0,05	0,05
mass flow	**G [kg/h]**	21435,00	28580,00	35725,00
medium density	**ρ1 [kg/m³]**	1128,000	1127,00	1125,00
absolute temp. (inlet side)	**T1 [K]**	92,90	93,00	92,90
spec. volume at p2 and t1	**V2 [m³/kg]**	0,07	0,07	0,07
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,13	0,13	0,13

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	90,45	120,72	151,22
Kv_tot	90,45	120,72	151,22
travel (%) (first give Kvs-value!)	66,15	73,53	79,29
selected Kvs-value	**Kvs=**	**340,00**	
valve type	globe valve		

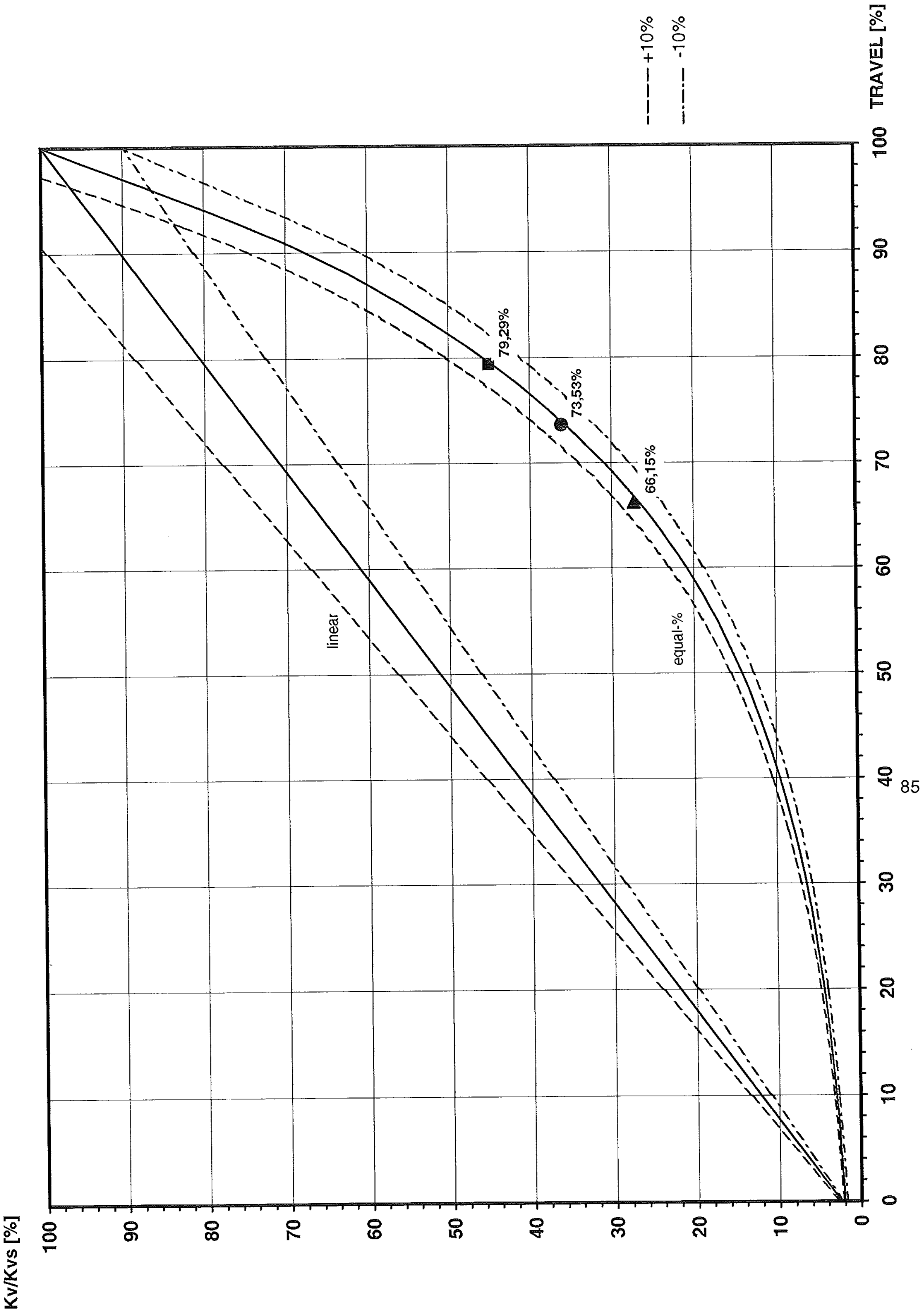
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV61210** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **PV61270** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

RECYCLE LOX PUMP 1

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
volume flow	**Q [m³/h]**	1,91	25,43	31,76
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	1500,00	20000,00	25000,00
charge pressure (abs.)	**p1 [bar]**	29,000	29,00	29,00
discharge pressure (abs.)	**p2 [bar]**	3,999	4,03	4,01
pressure loss	**Δp [bar]**	25,001	24,97	24,99
mass flow	**G [kg/h]**	2143,50	28580,00	35725,00
medium density	**ρ1 [kg/m³]**	1125,000	1124,00	1125,00
absolute temp. (inlet side)	**T1 [K]**	94,80	95,00	94,80
spec. volume at p2 and t1	**V2 [m³/kg]**	0,06	0,06	0,06
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,02	0,02	0,02

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

RESULTS

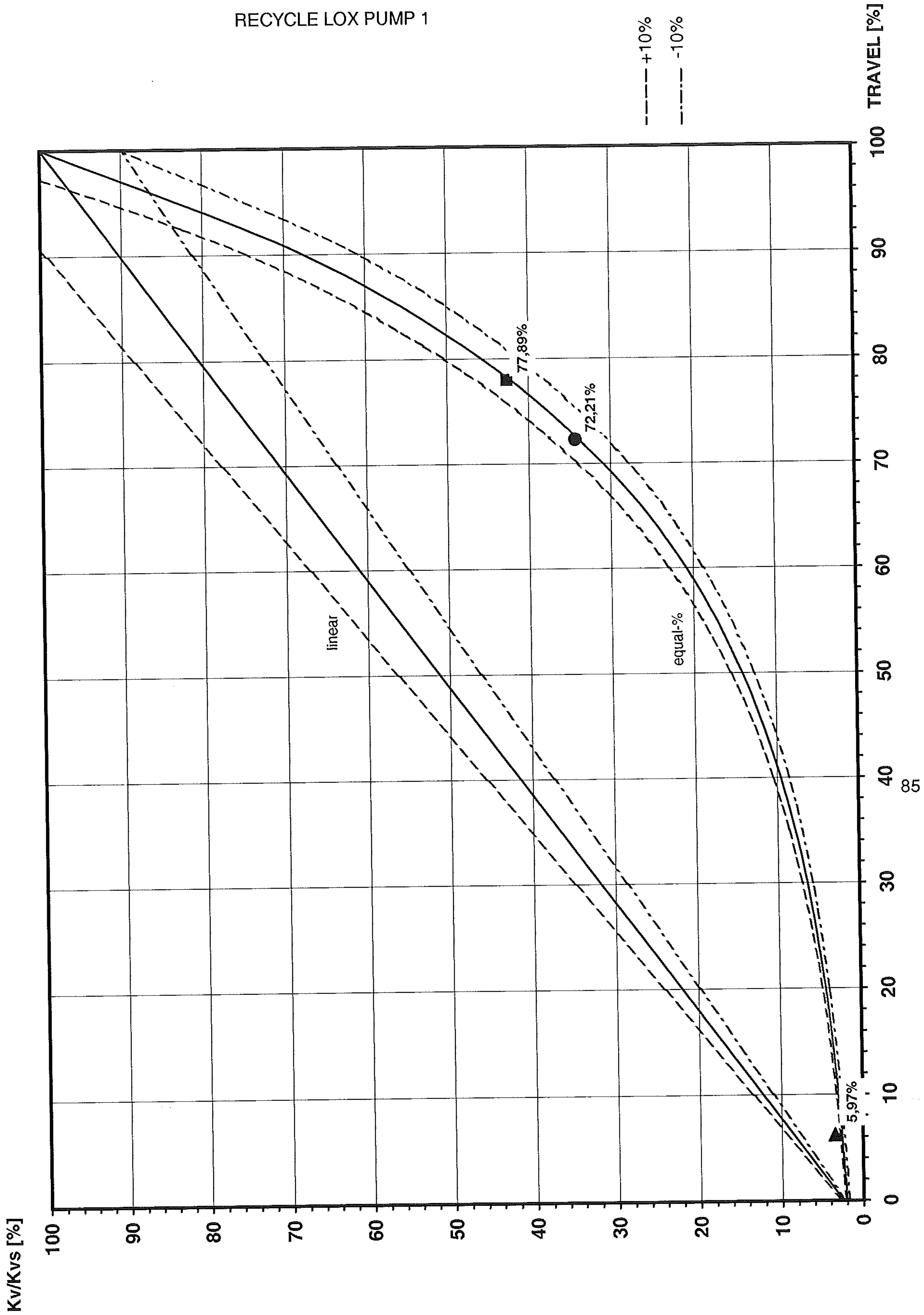
	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	0,40	5,39	6,74
Kv_tot	0,40	5,39	6,74
travel (%) (first give Kvs-value!)	5,97	72,21	77,89
selected Kvs-value	**Kvs=**	**16,00**	
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **PV61270** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:

RECYCLE LOX PUMP 1



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HK70001** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1}\sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	2277,87	2277,87	2277,87
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	15000,00	15000,00	15000,00
charge pressure (abs.)	**p1 [bar]**	1,12	1,13	1,13
discharge pressure (abs.)	**p2 [bar]**	1,09	1,10	1,10
pressure loss	**Δp [bar]**	0,030	0,03	0,03
mass flow	**G [kg/h]**	18756,00	18756,00	18756,00
medium density	**ρ1 [kg/m³]**	8,23	8,23	8,23
absolute temp. (inlet side)	**T1 [K]**	292,40	293,00	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,80	0,79	0,80
spec. volume at p1/2 and t1	**V* [m³/kg]**	1,55	1,54	1,56

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	3085,80	3074,89	3091,11
travel (%) (first give Kvs-value!)	86,55	86,46	86,60
selected Kvs-value	**Kvs=**	**5222,00**	
valve type	**butterfly valve**		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

0	19.01.2005	Möller	Eichler	Initial Version					
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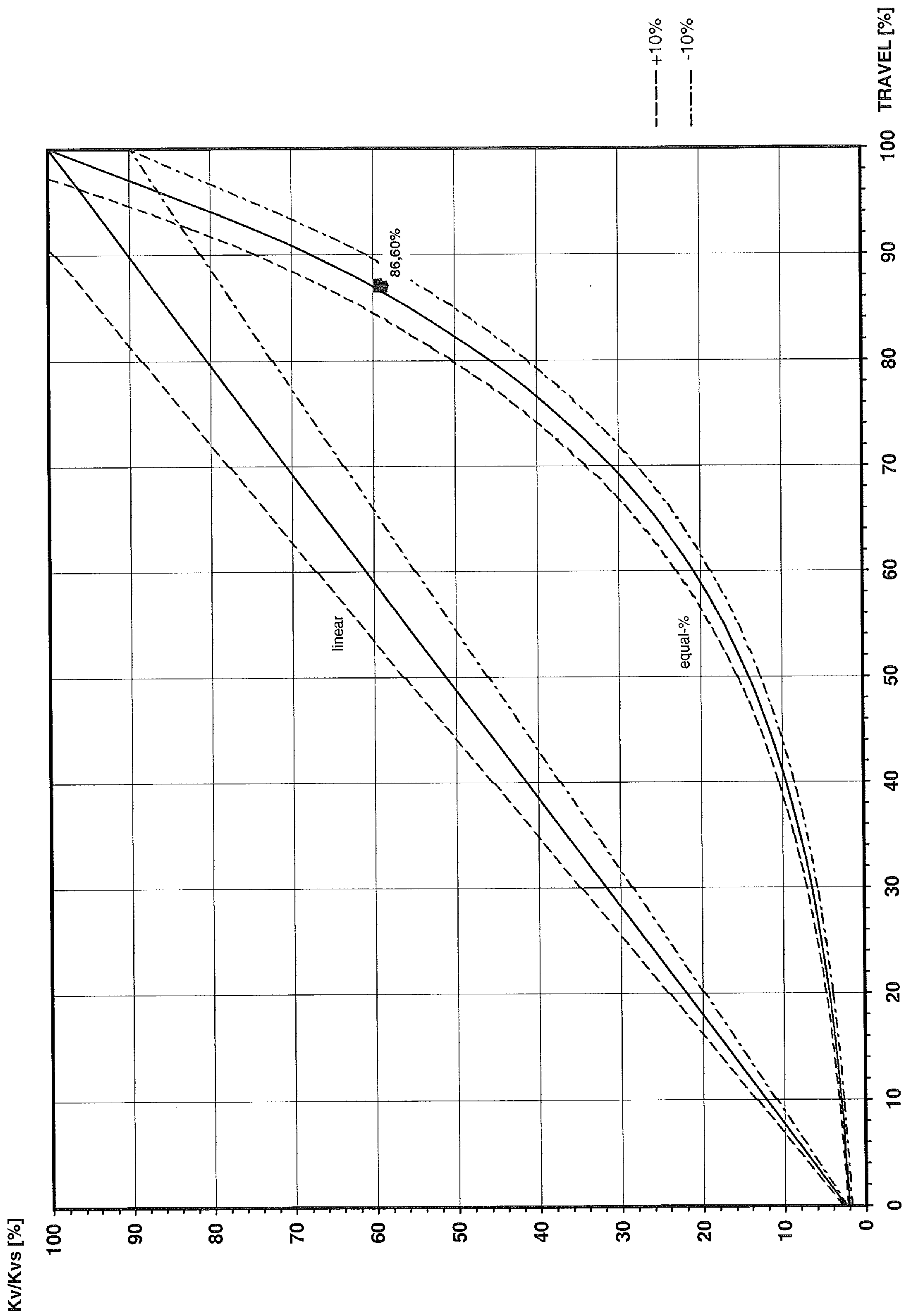
AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HK70001** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV70035** Project-No.: K70035
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^*\Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1}\sqrt{\rho_N{}^*T1}$	$K_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
volume flow	Q [m³/h]	759,29	1518,58	2277,87
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	5000,00	10000,00	15000,00
charge pressure (abs.)	p1 [bar]	7,300	7,30	7,30
discharge pressure (abs.)	p2 [bar]	5,800	5,80	5,80
pressure loss	Δp [bar]	1,500	1,50	1,50
mass flow	G [kg/h]	6252,00	12504,00	18756,00
medium density	ρ1 [kg/m³]	8,234	8,23	8,23
absolute temp. (inlet side)	T1 [K]	299,00	299,00	299,00
spec. volume at p2 and t1	V2 [m³/kg]	0,15	0,15	0,15
spec. volume at p1/2 and t1	V* [m³/kg]	0,24	0,24	0,24

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	63,77	127,54	191,31
travel (%) (first give Kvs-value!)	65,08	82,80	93,16
selected Kvs-value	Kvs=	250,00	
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

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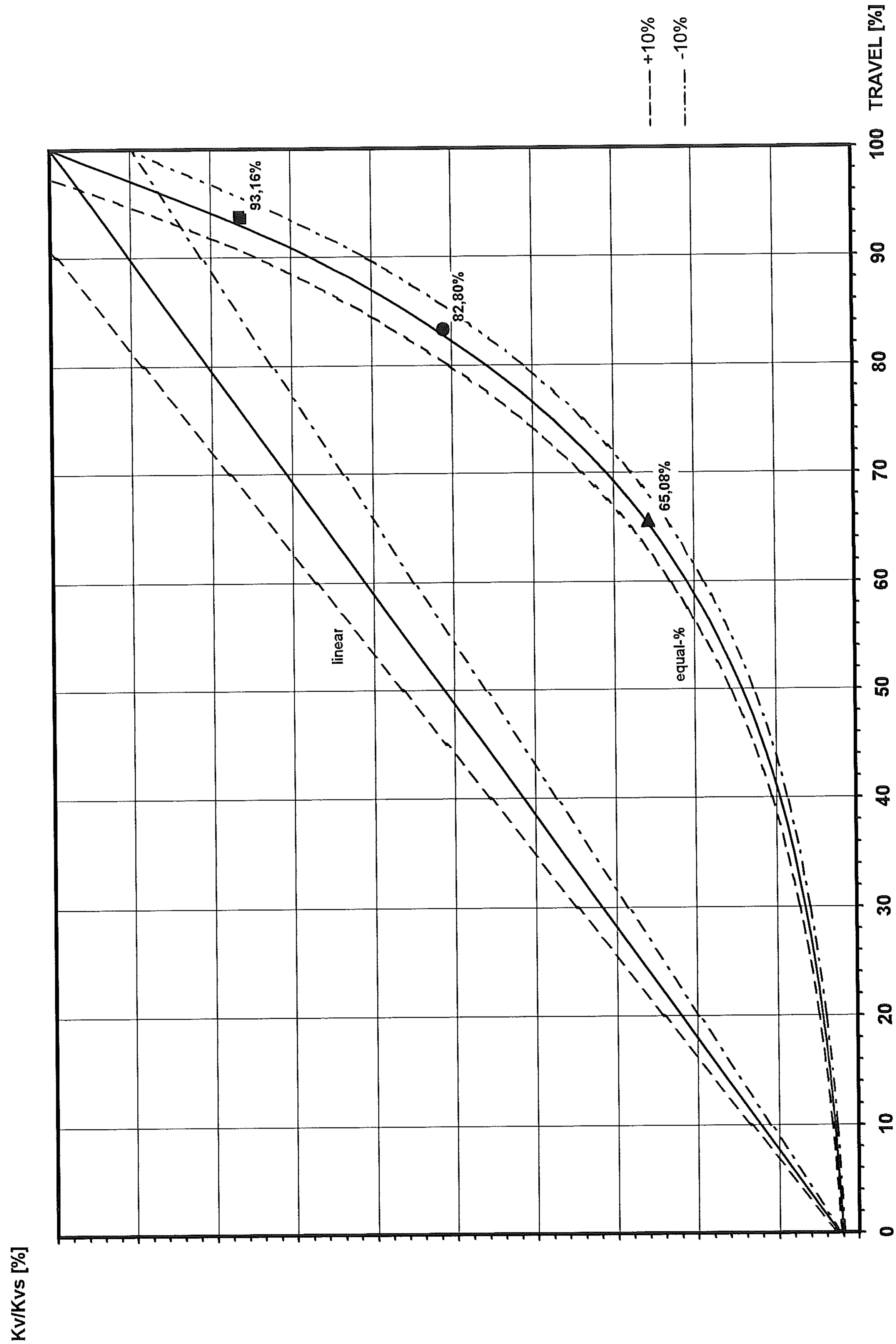
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV70035** Project No.: K70035
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV77035**
		Project-No.: K70035
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value

	liquids		gases		steam
pressure gradient	flow (m³/h)	flow (kg/h)	flow (m³/h)	flow (kg/h)	flow (kg/h)
subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	759,29	1518,58	2277,87
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	5000,00	10000,00	15000,00
charge pressure (abs.)	**p1 [bar]**	7,300	7,30	7,30
discharge pressure (abs.)	**p2 [bar]**	5,800	5,80	5,80
pressure loss	**Δp [bar]**	1,500	1,50	1,50
mass flow	**G [kg/h]**	6252,00	12504,00	18756,00
medium density	**ρ1 [kg/m³]**	8,234	8,23	8,23
absolute temp. (inlet side)	**T1 [K]**	299,00	299,00	299,00
spec. volume at p2 and t1	**V2 [m³/kg]**	0,15	0,15	0,15
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,24	0,24	0,24

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	63,77	127,54	191,31
travel (%) (first give Kvs-valuel)	65,08	82,80	93,16
selected Kvs-value	**Kvs=**	**250,00**	
valve type		globe valve	

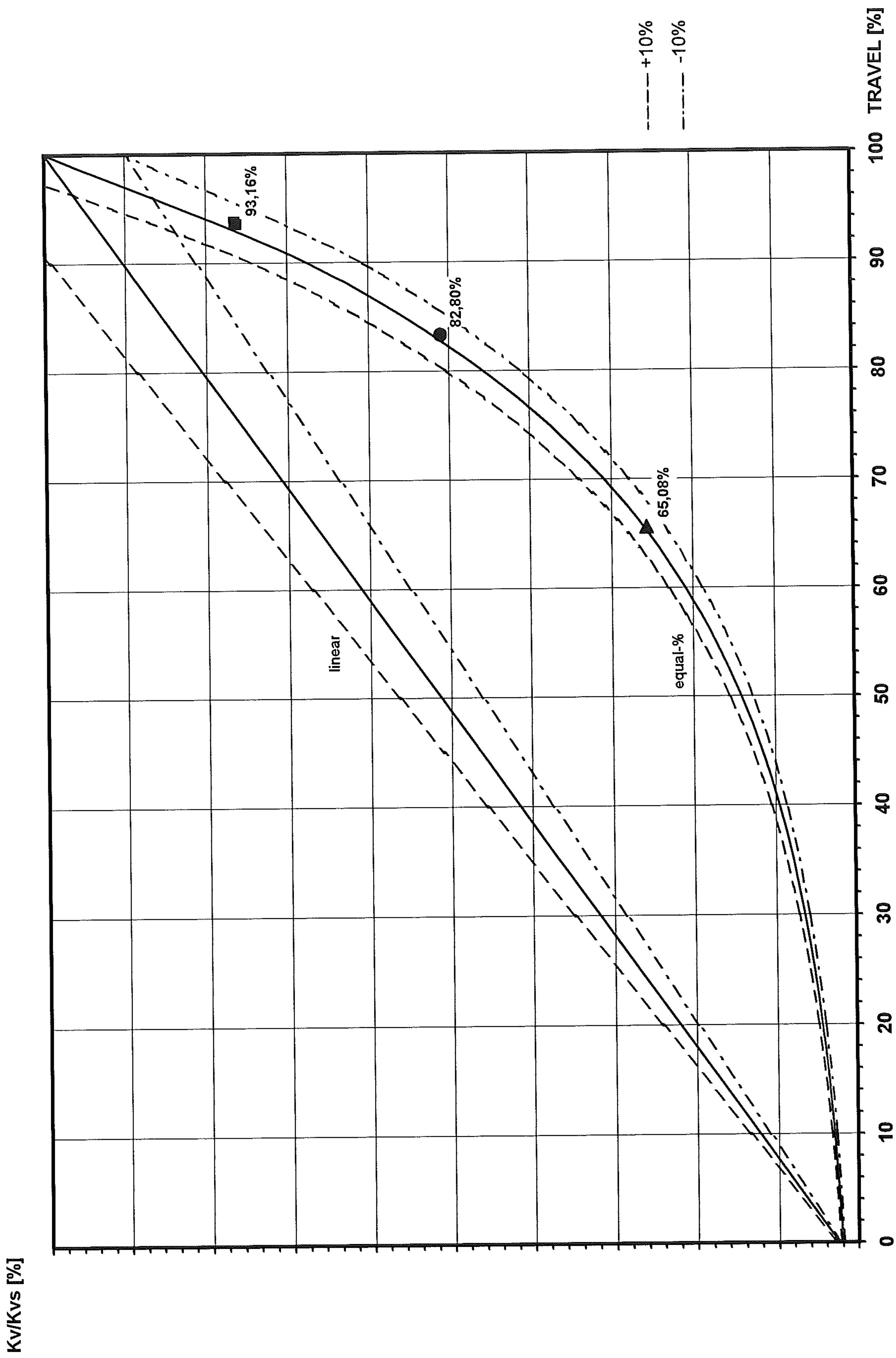
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV77035** Project No.: K70035
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
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AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HK70036** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value

pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	2277,87	2277,87	2277,87
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	15000,00	15000,00	15000,00
charge pressure (abs.)	**p1 [bar]**	7,30	7,30	7,30
discharge pressure (abs.)	**p2 [bar]**	7,25	7,25	7,25
pressure loss	**Δp [bar]**	0,050	0,05	0,05
mass flow	**G [kg/h]**	18756,00	18756,00	18756,00
medium density	**ρ1 [kg/m³]**	8,23	8,23	8,23
absolute temp. (inlet side)	**T1 [K]**	299,00	299,00	299,00
spec. volume at p2 and t1	**V2 [m³/kg]**	0,12	0,12	0,12
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,24	0,24	0,24

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	937,20	937,20	937,20
travel (%) (first give Kvs-value!)	81,21	81,21	81,21
selected Kvs-value	**Kvs=**	**1955,00**	
valve type	**globe valve**		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

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0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HK70036** Project No.: K70101
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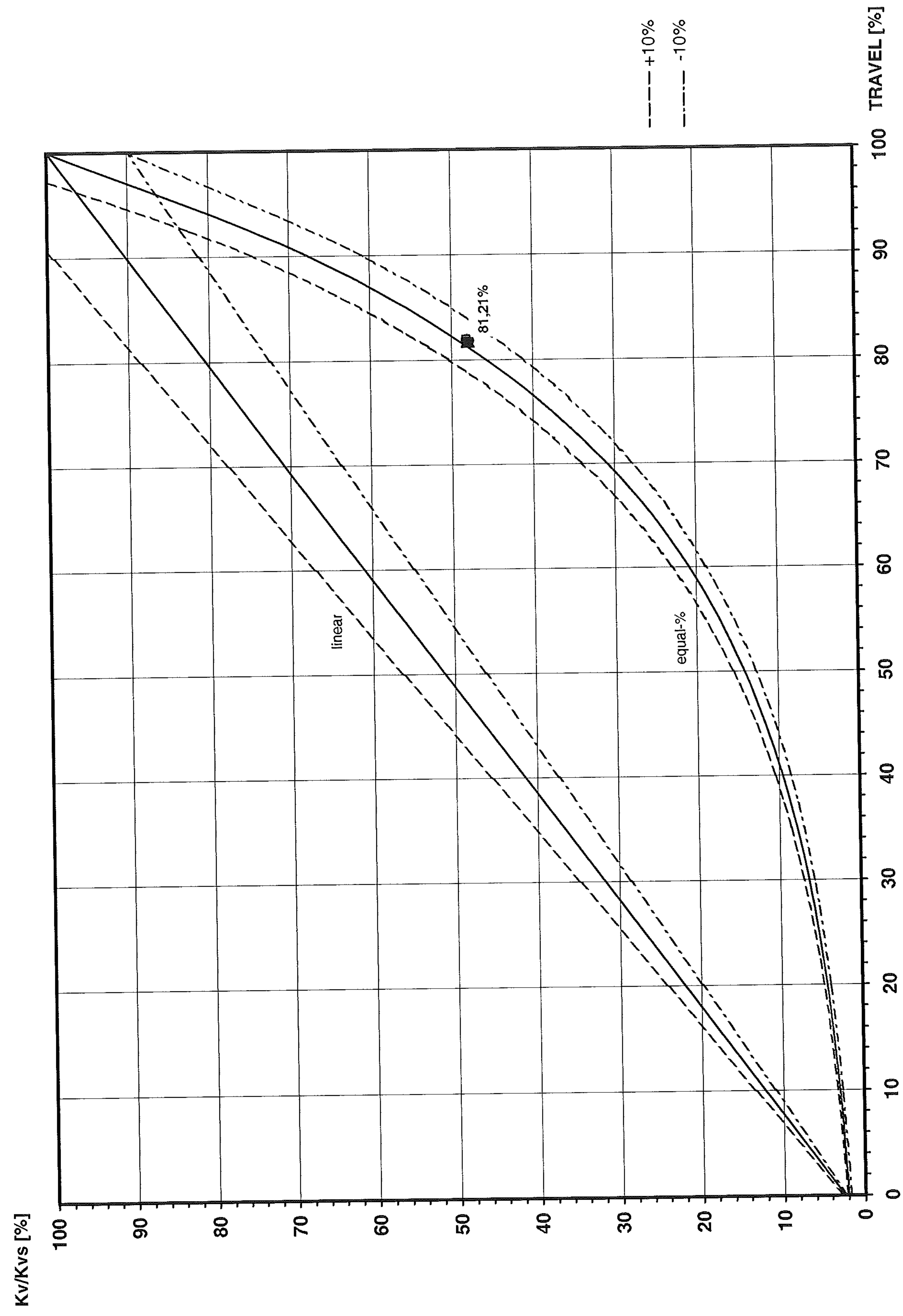

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Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HK70041**
		Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	4479,82	3049,01	2439,21
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	29500,00	20000,00	16000,00
charge pressure (abs.)	**p1 [bar]**	7,06	7,06	7,06
discharge pressure (abs.)	**p2 [bar]**	7,00	7,00	7,00
pressure loss	**Δp [bar]**	0,06	0,06	0,06
mass flow	**G [kg/h]**	36886,80	25008,00	20006,40
medium density	**ρ1 [kg/m³]**	8,23	8,20	8,20
absolute temp. (inlet side)	**T1 [K]**	299,00	288,00	288,00
spec. volume at p2 and t1	**V2 [m³/kg]**	0,13	0,12	0,12
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,25	0,24	0,24

	RESULTS		
	case 1	**case 2**	**case 3**
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	1712,36	1139,37	911,49
travel (%) (first give Kvs-value!)	71,61	61,19	55,49
selected Kvs-value	**Kvs=**	**5200,00**	
valve type	**butterfly valve**		

STANDARD DENSITIES OF COMMON GASES		
gas	**chemical symbol**	**density ρ_N kg/m³**
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Required Valve Size:
DN 350

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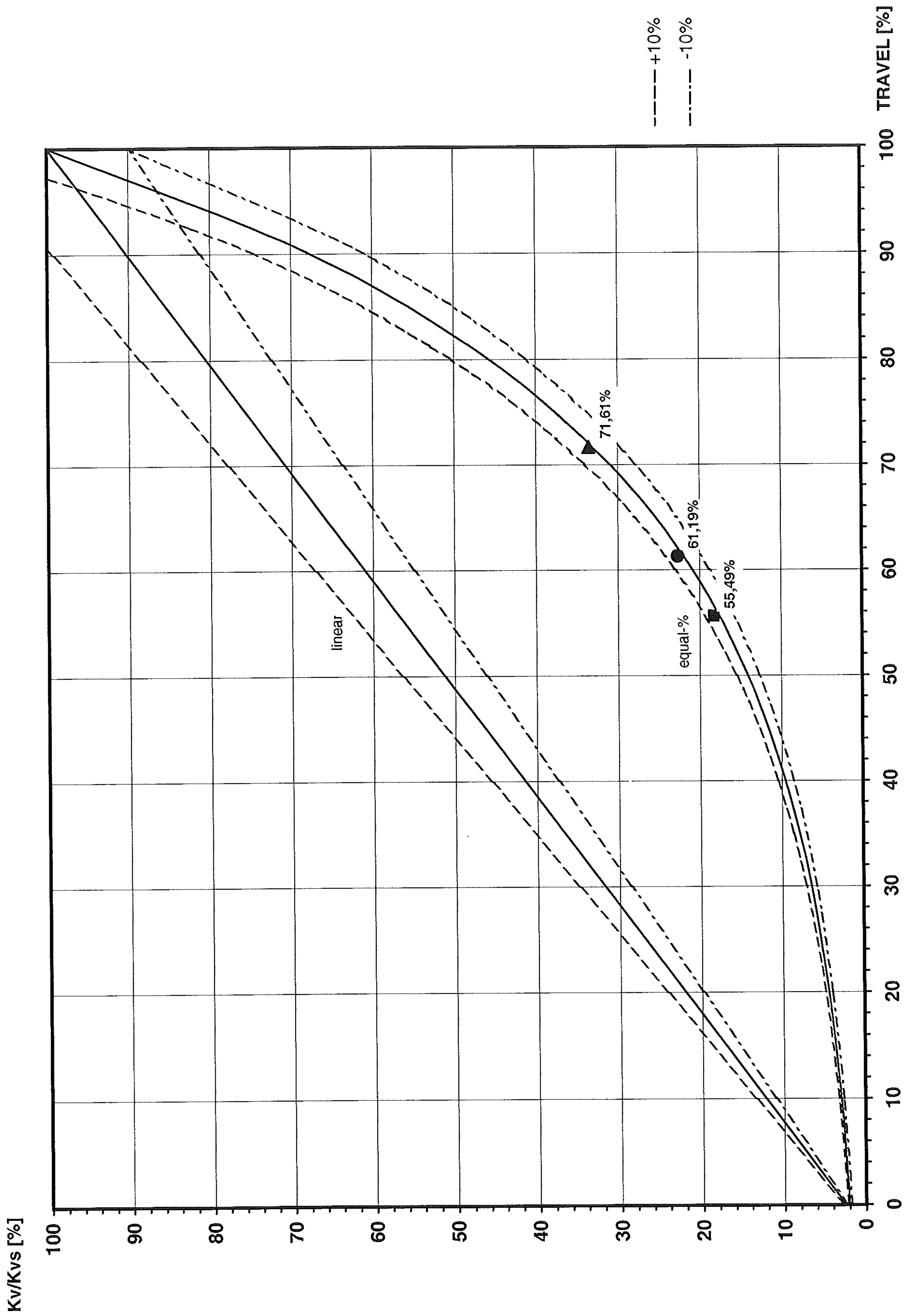
AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.:	**HK70041**
		Project No.:	K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page:	of:



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Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV71110** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
volume flow	Q [m³/h]	6,08	6,09	6,10
standard flow (0°C, 1,013 bar)	Q_N [Nm³/h]	3500,00	3500,00	3500,00
charge pressure (abs.)	p1 [bar]	6,229	6,31	6,35
discharge pressure (abs.)	p2 [bar]	6,179	6,26	6,30
pressure loss	Δp [bar]	0,050	0,05	0,05
mass flow	G [kg/h]	4376,40	4376,40	4376,40
medium density	ρ1 [kg/m³]	720,000	719,00	718,00
absolute temp. (inlet side)	T1 [K]	94,50	94,70	94,80
spec. volume at p2 and t1	V2 [m³/kg]	0,05	0,04	0,04
spec. volume at p1/2 and t1	V* [m³/kg]	0,09	0,09	0,09

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	22,96	23,08	23,21
Kv_tot	22,96	23,08	23,21
travel (%) (first give Kvs-value!)	74,19	74,33	74,47
selected Kvs-value	Kvs= 63,00		
valve type	globe valve		

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

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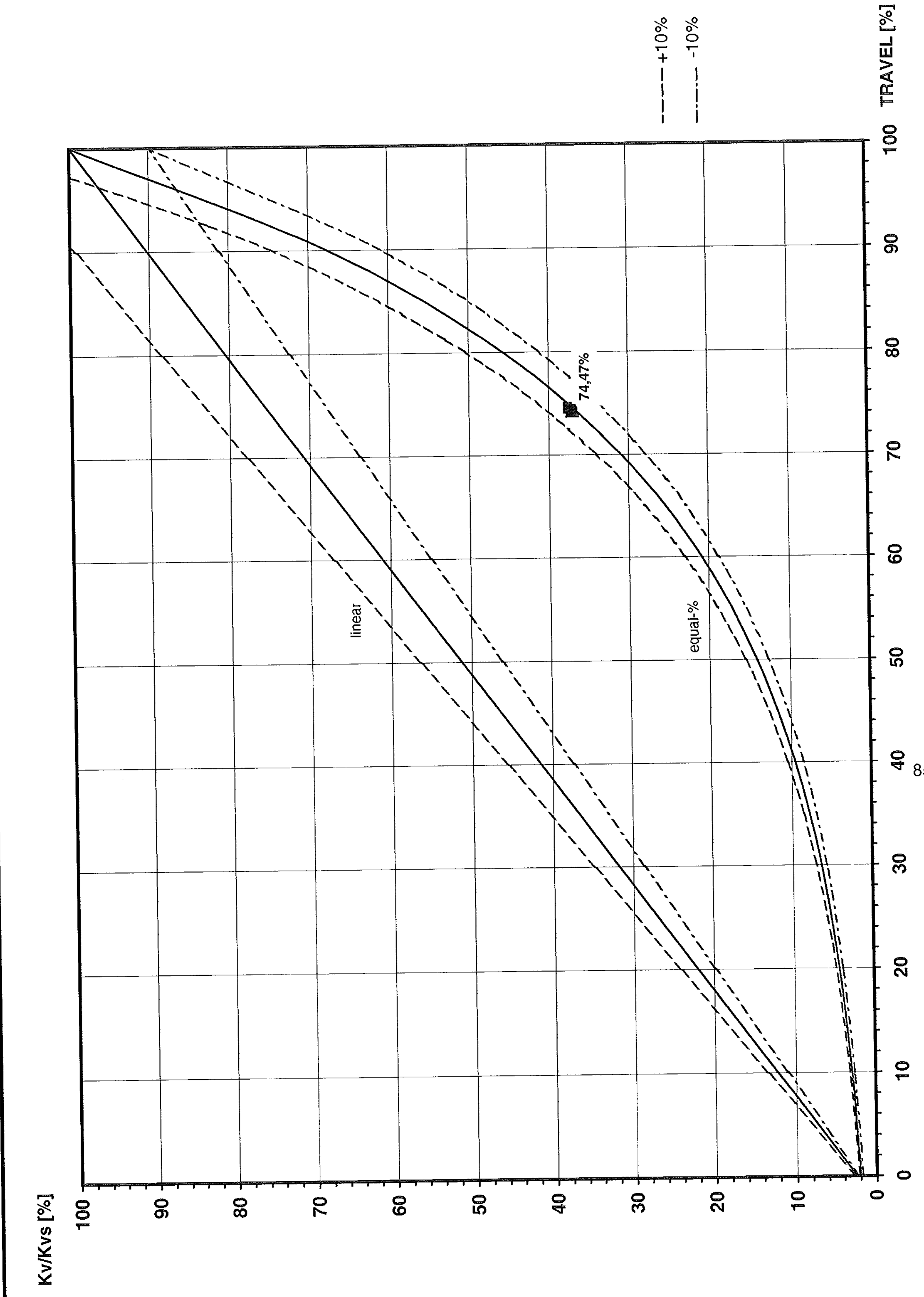
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV71110** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

HV71110_calc.XLS

SPEZ80DE XLS 25.08.1997

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

TAG - No.: **PV71170**

Project-No.: K70101

Project: **ASU No. 9 KOSICE**

Page: of:

RECYCLE LOX PUMP 1

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	0,79	2,38	5,56
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	500,00	1500,00	3500,00
charge pressure (abs.)	**p1 [bar]**	22,000	22,00	22,00
discharge pressure (abs.)	**p2 [bar]**	6,423	6,42	6,42
pressure loss	**Δp [bar]**	15,577	15,58	15,58
mass flow	**G [kg/h]**	625,20	1875,60	4376,40
medium density	**ρ1 [kg/m³]**	709,000	709,00	709,00
absolute temp. (inlet side)	**T1 [K]**	97,90	97,90	97,90
spec. volume at p2 and t1	**V2 [m³/kg]**	0,05	0,05	0,05
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,03	0,03	0,03

RESULTS

	case 1	**case 2**	**case 3**
pressure gradient	supercritical	supercritical	supercritical
flash (%)	10,00	10,00	10,00
Kv_flash	0,10	0,29	0,68
Kv_liquid	0,17	0,51	1,19
Kv_tot	0,27	0,80	1,87
travel (%) (first give Kvs-value!)	19,21	47,29	68,95
selected Kvs-value	**Kvs=**	**6,30**	
valve type	**globe valve**		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

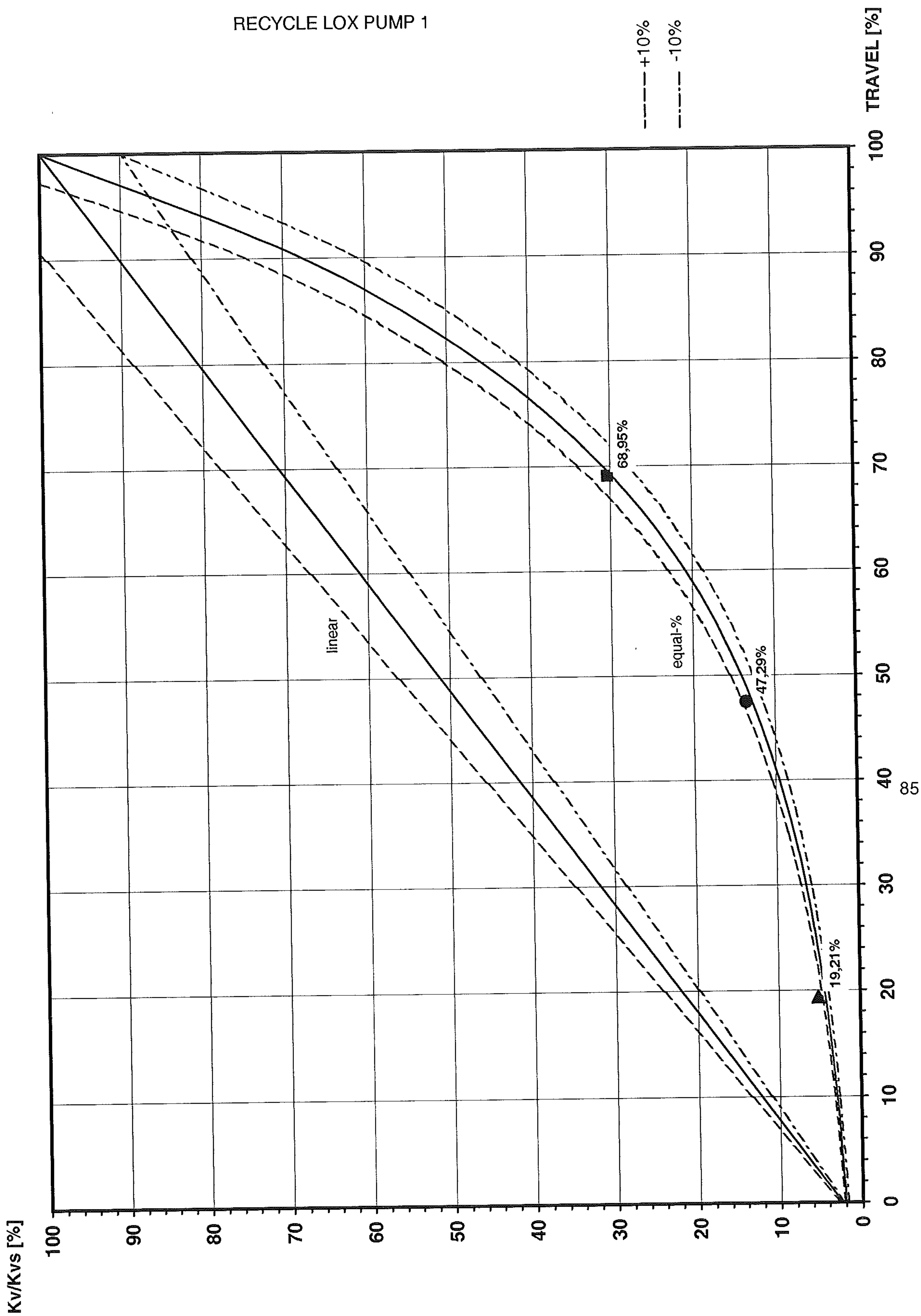
gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

85

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **PV71170** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:

RECYCLE LOX PUMP 1



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

PV71170_calc.XLS

SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV71210** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^*T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	6,08	6,09	6,10
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	3500,00	3500,00	3500,00
charge pressure (abs.)	**p1 [bar]**	6,229	6,31	6,35
discharge pressure (abs.)	**p2 [bar]**	6,179	6,26	6,30
pressure loss	**Δp [bar]**	0,050	0,05	0,05
mass flow	**G [kg/h]**	4376,40	4376,40	4376,40
medium density	**ρ1 [kg/m³]**	720,000	719,00	718,00
absolute temp. (inlet side)	**T1 [K]**	94,50	94,70	94,80
spec. volume at p2 and t1	**V2 [m³/kg]**	0,05	0,04	0,04
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,09	0,09	0,09

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid	22,96	23,08	23,21
Kv_tot	22,96	23,08	23,21
travel (%) (first give Kvs-value!)	74,19	74,33	74,47
selected Kvs-value	**Kvs=**	**63,00**	
valve type	globe valve		

STANDARD DENSITIES OF COMMON GASES

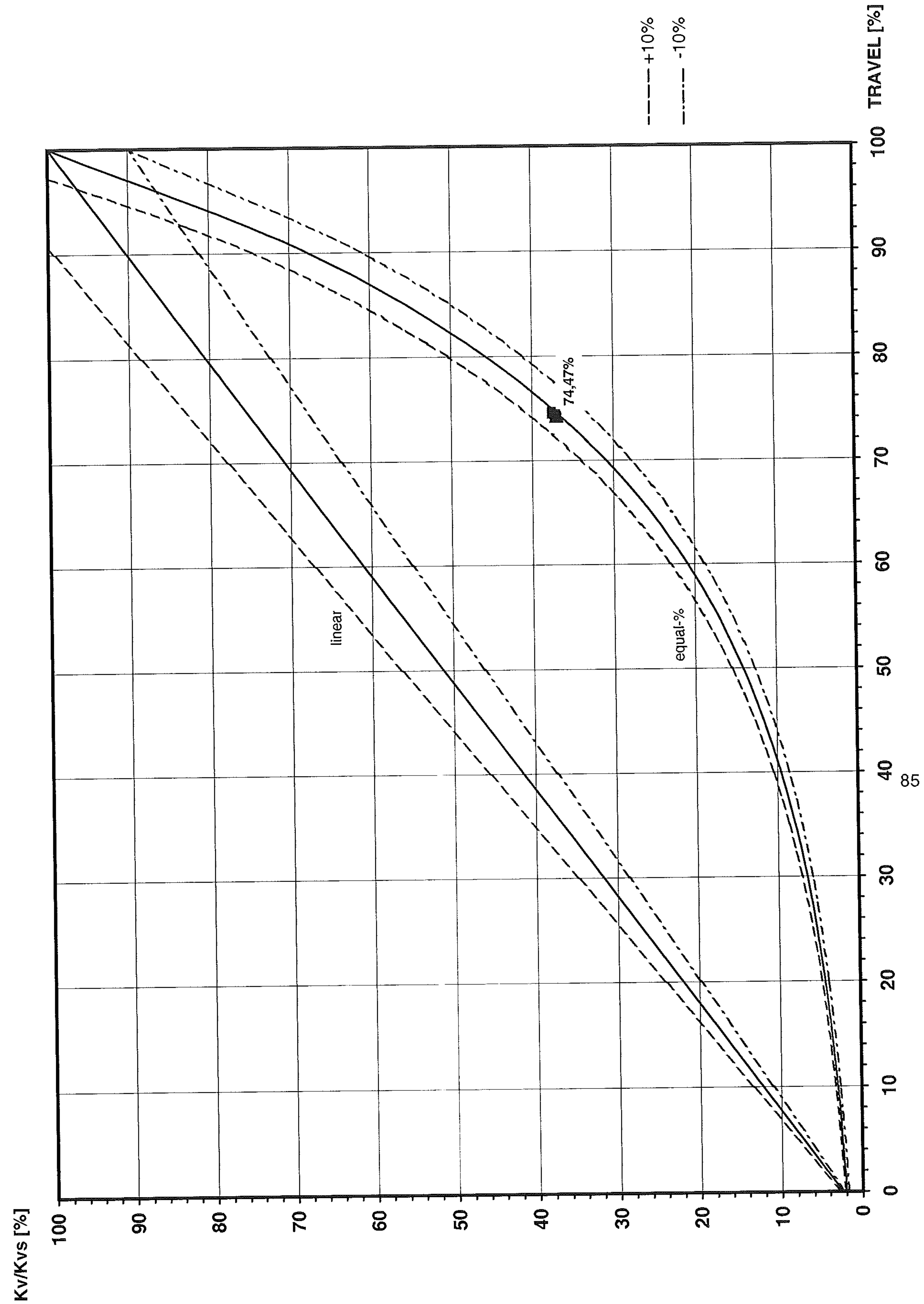
gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

HV71210_calc.XLS SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV71210** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

HV71210_calc XLS

SPEZ80DE.XLS 25.08.1997

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **PV71270**
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Project-No.: K70101
		Page: of:

RECYCLE LOX PUMP 1

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	0,79	2,38	5,56
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	500,00	1500,00	3500,00
charge pressure (abs.)	**p1 [bar]**	22,000	22,00	22,00
discharge pressure (abs.)	**p2 [bar]**	6,423	6,42	6,42
pressure loss	**Δp [bar]**	15,577	15,58	15,58
mass flow	**G [kg/h]**	625,20	1875,60	4376,40
medium density	**ρ1 [kg/m³]**	709,000	709,00	709,00
absolute temp. (inlet side)	**T1 [K]**	97,90	97,90	97,90
spec. volume at p2 and t1	**V2 [m³/kg]**	0,05	0,05	0,05
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,03	0,03	0,03

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	supercritical
flash (%)	10,00	10,00	10,00
Kv_flash	0,10	0,29	0,68
Kv_liquid	0,17	0,51	1,19
Kv_tot	0,27	0,80	1,87
travel (%) (first give Kvs-value!)	19,21	47,29	68,95
selected Kvs-value	**Kvs=**	**6,30**	
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

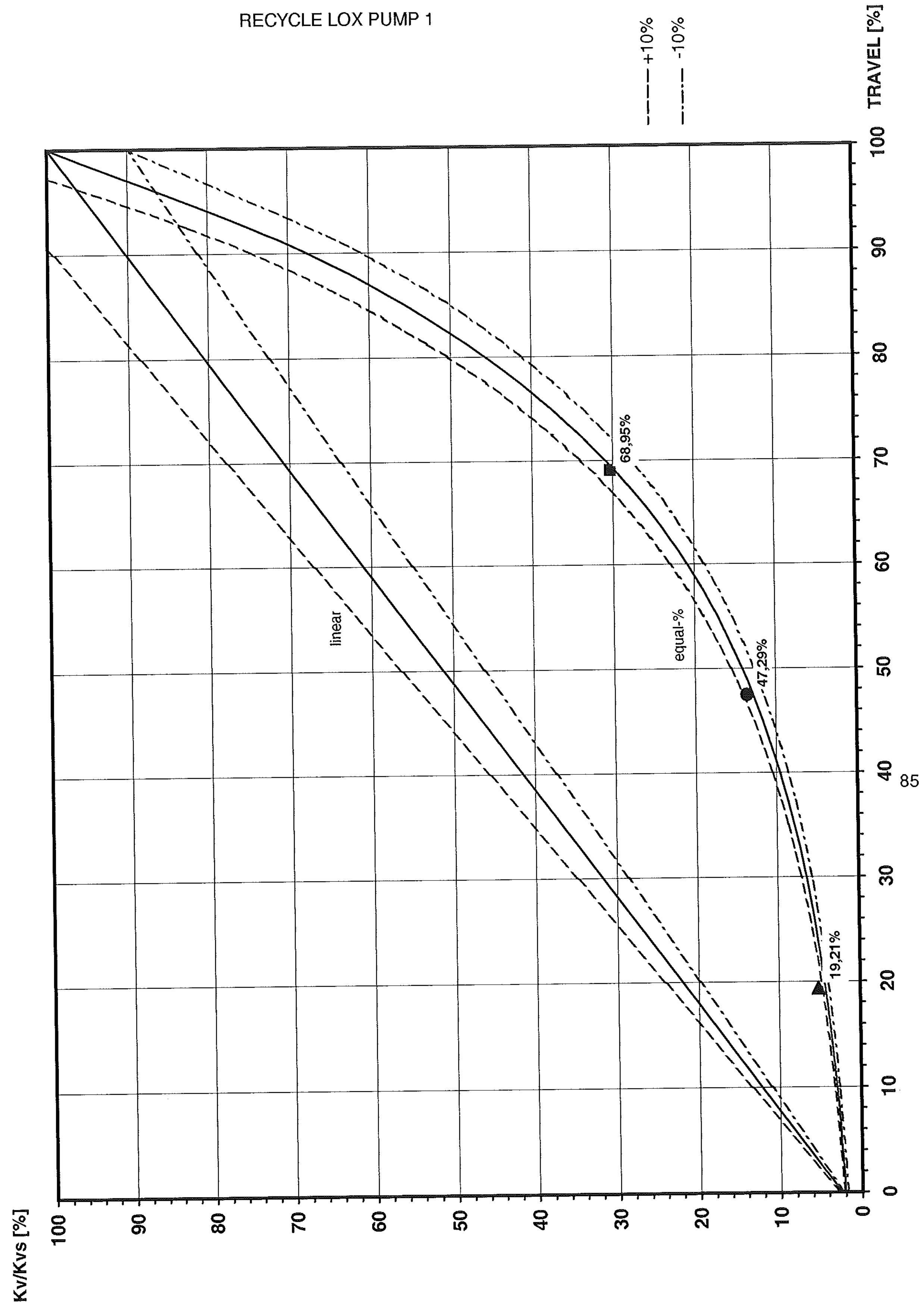
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **PV71270** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:

RECYCLE LOX PUMP 1



0	17.11.2004	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE

Air Liquide AGS GmbH

Specification

Calculation of Control (Butterfly-)Valves

Project: **ASU No. 9 KOSICE**

TAG - No.: **HV73001**

Project-No.: K70101

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	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$K_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$K_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$K_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$K_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$K_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$K_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$K_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	1,10		
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	700,00		
charge pressure (abs.)	**p1 [bar]**	9,880		
discharge pressure (abs.)	**p2 [bar]**	5,330		
pressure loss	**Δp [bar]**	4,550		
mass flow	**G [kg/h]**	875,28		
medium density	**ρ1 [kg/m³]**	635,000		
absolute temp. (inlet side)	**T1 [K]**	103,70		
spec. volume at p2 and t1	**V2 [m³/kg]**	0,06		
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,06		

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical		
flash (%)	20,00		
Kv_flash	0,63		
Kv_liquid	0,41		
Kv_tot	1,04		
travel (%) (first give Kvs-value!)	77,62		
selected Kvs-value	Kvs= 2,50		
valve type	globe valve		

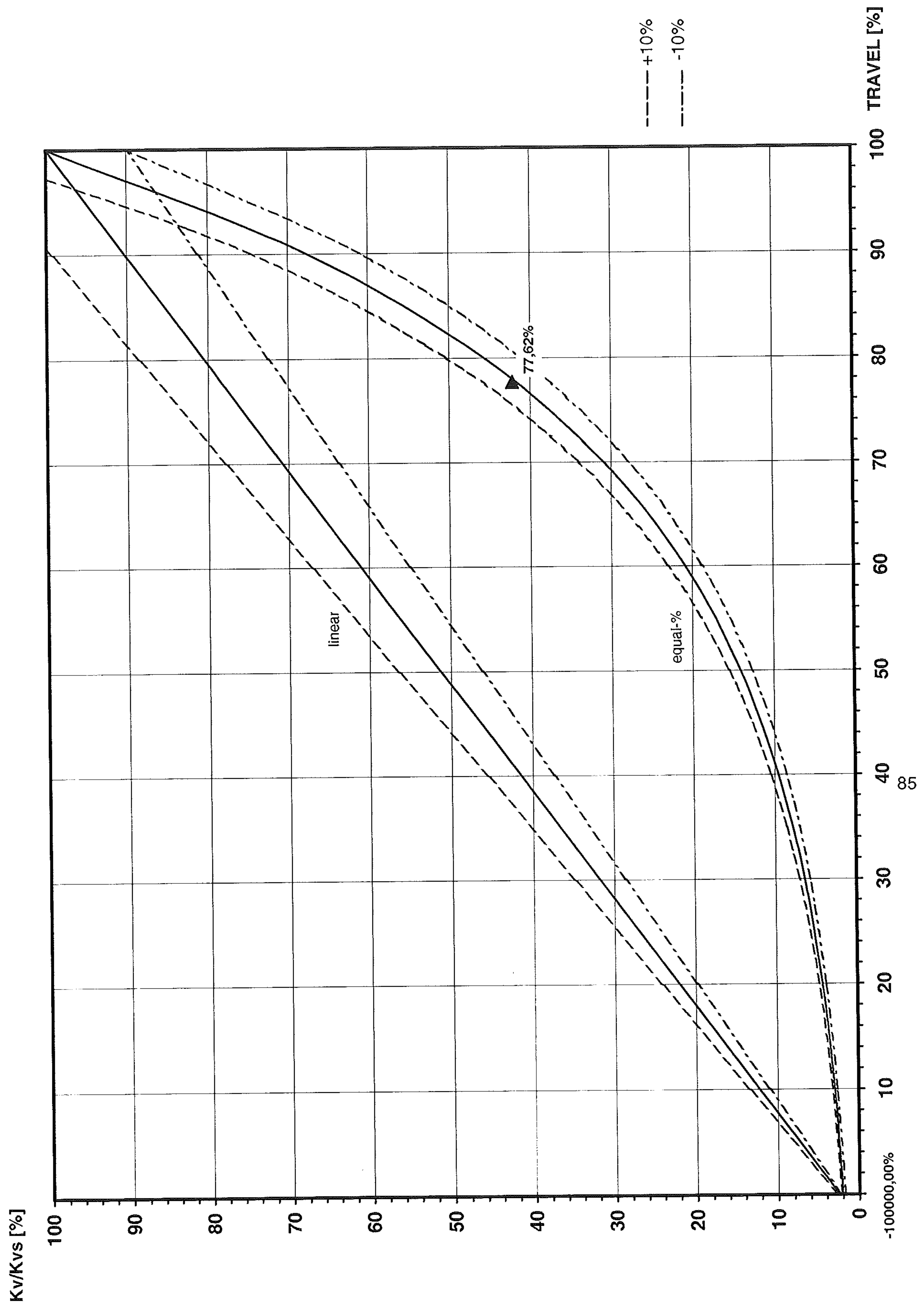
Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355 85

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	17.11.2004	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV73001** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



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Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HK77001** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids: flow (m³/h)	liquids: flow (kg/h)	gases: flow (m³/h)	gases: flow (kg/h)	steam: flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^*\sqrt{\frac{\rho 1}{1000^*\Delta p}}$	$k_v = \frac{G}{\sqrt{1000^*\rho 1^*\Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N{}^*T1}{\Delta p^*p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N{}^*\Delta p^*p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257p1}\sqrt{\rho_N{}^*T1}$	$k_v = \frac{G}{257p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	2277,87	2277,87	2277,87
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	15000,00	15000,00	15000,00
charge pressure (abs.)	**p1 [bar]**	1,12	1,13	1,13
discharge pressure (abs.)	**p2 [bar]**	1,09	1,10	1,10
pressure loss	**Δp [bar]**	0,030	0,03	0,03
mass flow	**G [kg/h]**	18756,00	18756,00	18756,00
medium density	**ρ1 [kg/m³]**	8,23	8,23	8,23
absolute temp. (inlet side)	**T1 [K]**	292,40	293,00	296,10
spec. volume at p2 and t1	**V2 [m³/kg]**	0,80	0,79	0,80
spec. volume at p1/2 and t1	**V* [m³/kg]**	1,55	1,54	1,56

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	3085,80	3074,89	3091,11
travel (%) (first give Kvs-value!)	86,55	86,46	86,60
selected Kvs-value	Kvs=	5222,00	
valve type	butterfly valve		

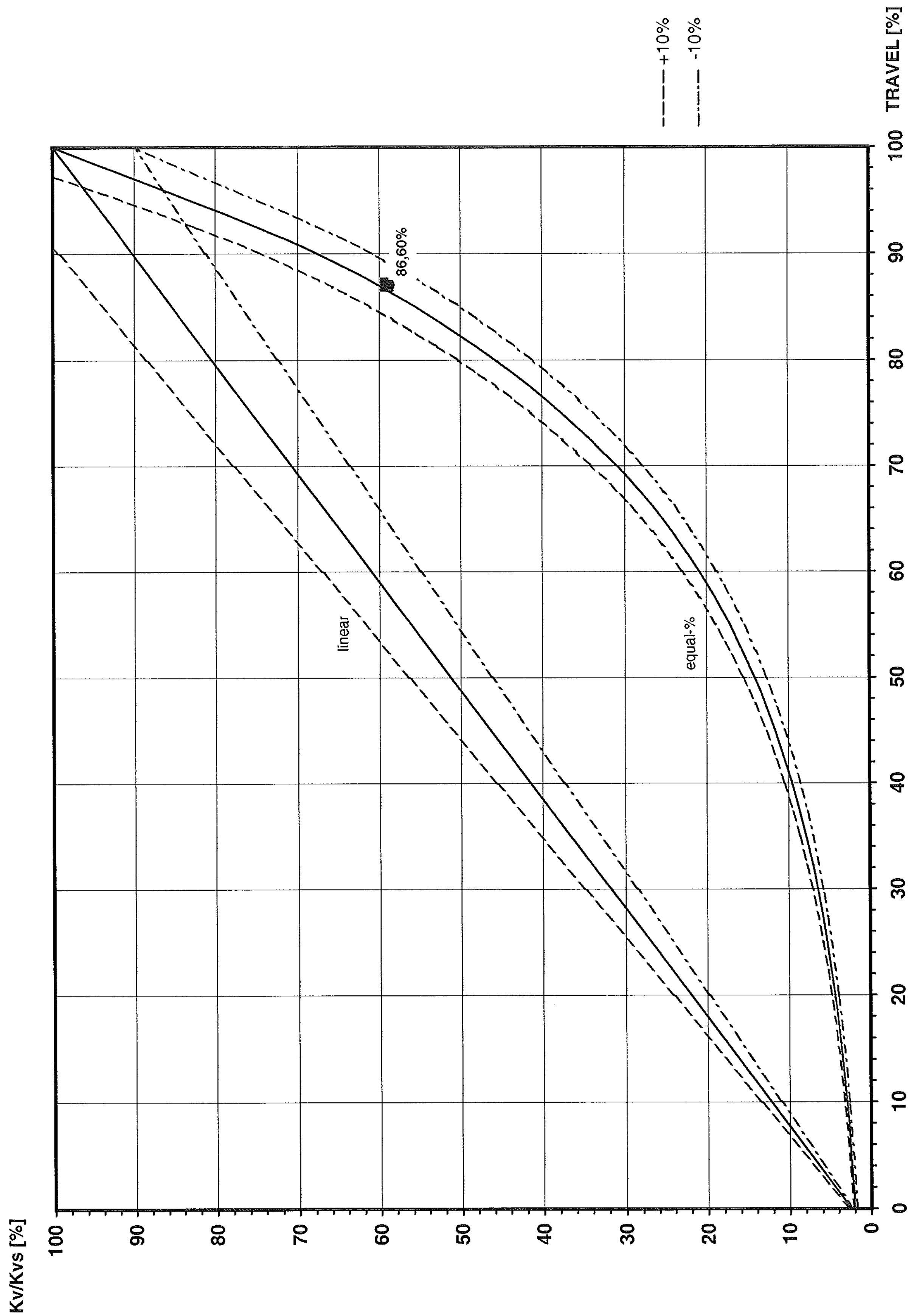
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HK77001** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HK77036**
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Project-No.: K70101 Page: of:

	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
calculation of Kv-value	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

		case 1	case 2	case 3
medium		nitrogen		
state		gaseous		
standard density		1,2504 kg/m³		
volume flow	**Q [m³/h]**	2277,87	2277,87	2277,87
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	15000,00	15000,00	15000,00
charge pressure (abs.)	**p1 [bar]**	7,30	7,30	7,30
discharge pressure (abs.)	**p2 [bar]**	7,25	7,25	7,25
pressure loss	**Δp [bar]**	0,050	0,05	0,05
mass flow	**G [kg/h]**	18756,00	18756,00	18756,00
medium density	**ρ1 [kg/m³]**	8,23	8,23	8,23
absolute temp. (inlet side)	**T1 [K]**	299,00	299,00	299,00
spec. volume at p2 and t1	**V2 [m³/kg]**	0,12	0,12	0,12
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,24	0,24	0,24

RESULTS

	case 1	case 2	case 3
pressure gradient	subcritical	subcritical	subcritical
flash (%)			
Kv_flash			
Kv_liquid			
Kv_tot	937,20	937,20	937,20
travel (%) (first give Kvs-value!)	81,21	81,21	81,21
selected Kvs-value	**Kvs= 1955,00**		
valve type	**globe valve**		

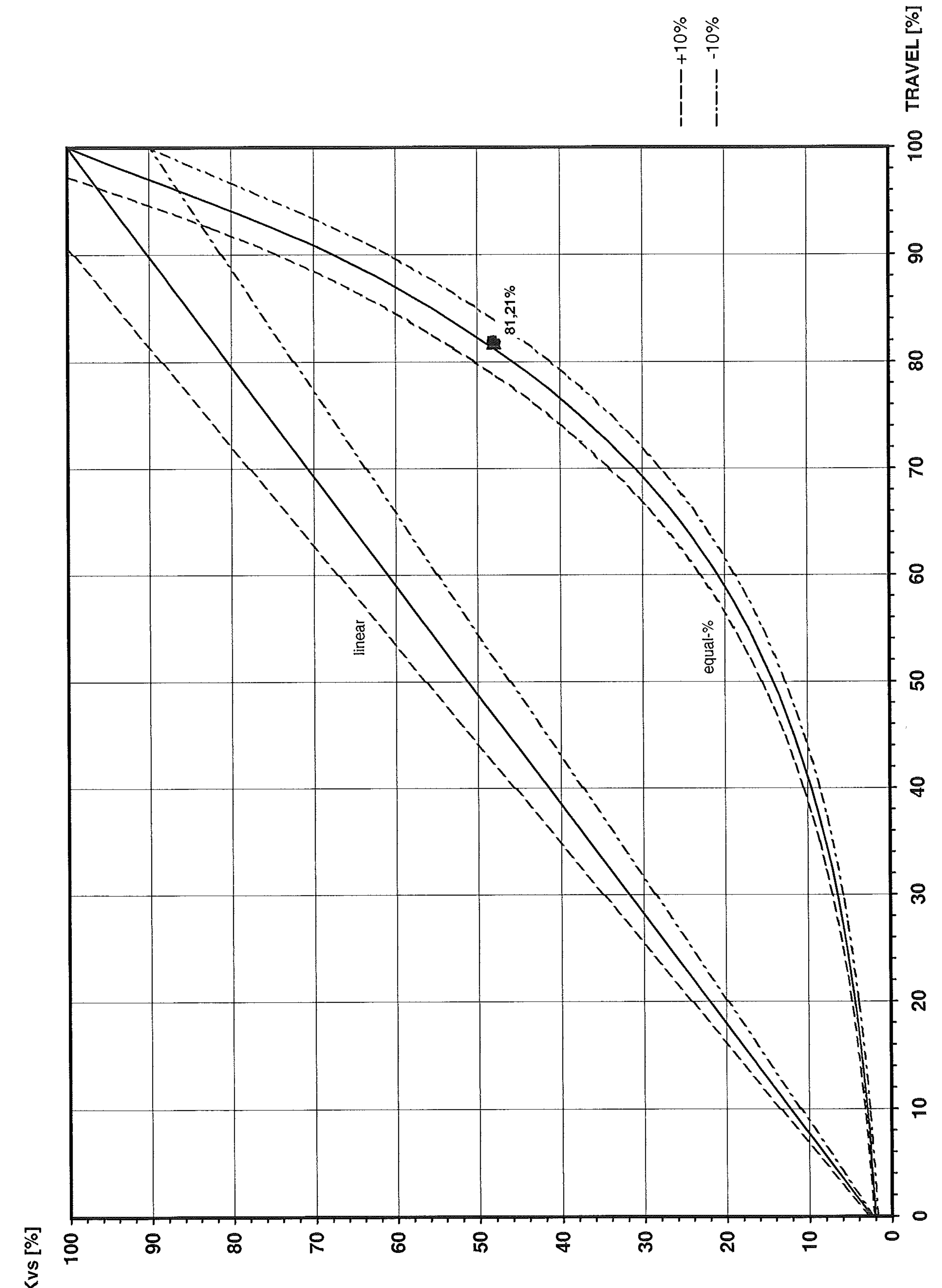
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HK77036** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV90013** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		nitrogen		
state		liquid		
standard density		1,2504 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	55,75	95,57	95,57
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	35000,00	60000,00	60000,00
charge pressure (abs.)	**p1 [bar]**	2,300	5,00	6,00
discharge pressure (abs.)	**p2 [bar]**	1,013	1,01	1,01
pressure loss	**Δp [bar]**	1,287	3,99	4,99
mass flow	**G [kg/h]**	43764,00	75024,00	75024,00
medium density	**ρ1 [kg/m³]**	785,000	785,00	785,00
absolute temp. (inlet side)	**T1 [K]**	81,60	81,60	81,60
spec. volume at p2 and t1	**V2 [m³/kg]**	0,24	0,24	0,24
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,21	0,10	0,08

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	43,54	42,41	37,92
Kv_tot	43,54	42,41	37,92
travel (%) (first give Kvs-value!)	97,78	97,10	94,24
selected Kvs-value	**Kvs=**	**47,50**	
valve type	**globe valve**		

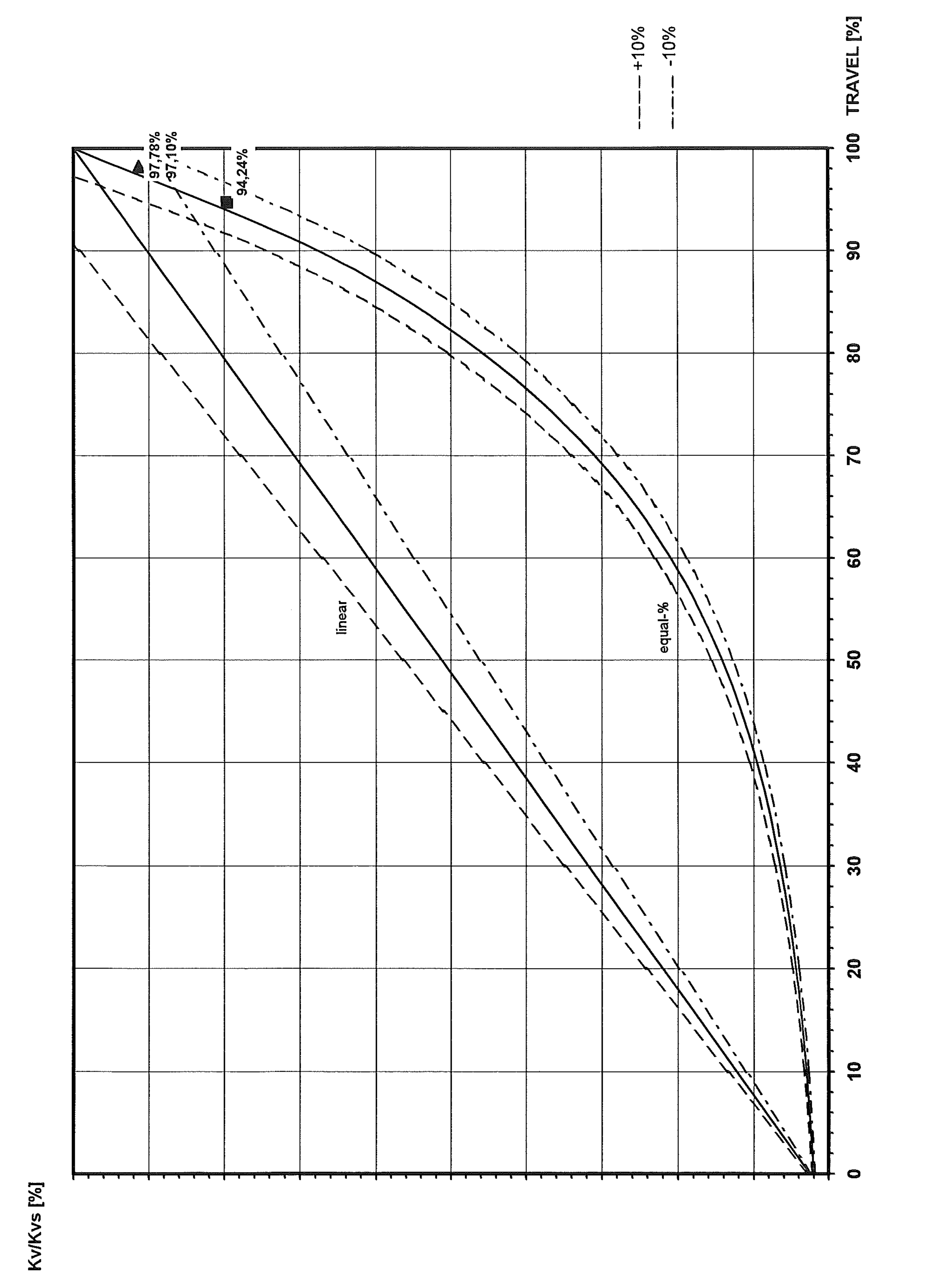
STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Travel indication only depends on valves with equal-% characteristic.

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV90013** Project No.: K70101
Air Liquide AGS GmbH	Projekt: **ASU No. 9 KOSICE**	Page: of:



0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

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AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV90014** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value

pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
subcritical $p2 > \frac{p1}{2}$, $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho 1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho 1^* \Delta p}}$	$k_v = \frac{Q_N}{514} \sqrt{\frac{\rho_N{}^*T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514} \sqrt{\frac{T1}{\rho_N{}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{V2}{\Delta p}}$
supercritical $p2 < \frac{p1}{2}$, $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1} \sqrt{\rho_N{}^*T1}$	$k_v = \frac{G}{257 p1} \sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}} \sqrt{\frac{2V^*}{p1}}$

SERVICE CONDITIONS

medium		oxygen		
state		liquid		
standard density		1,4290 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	115,45	192,41	192,24
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	90000,00	150000,00	150000,00
charge pressure (abs.)	**p1 [bar]**	2,800	5,00	6,00
discharge pressure (abs.)	**p2 [bar]**	1,013	1,01	1,01
pressure loss	**Δp [bar]**	1,787	3,99	4,99
mass flow	**G [kg/h]**	128610,00	214350,00	214350,00
medium density	**ρ1 [kg/m³]**	1114,000	1114,00	1115,00
absolute temp. (inlet side)	**T1 [K]**	95,60	95,60	95,60
spec. volume at p2 and t1	**V2 [m³/kg]**	0,25	0,25	0,25
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,18	0,10	0,08

RESULTS

	case 1	case 2	case 3
pressure gradient	supercritical	supercritical	supercritical
flash (%)			
Kv_flash			
Kv_liquid	91,15	101,71	90,90
Kv_tot	91,15	101,71	90,90
travel (%) (first give Kvs-value!)	91,93	94,73	91,86
selected Kvs-value	**Kvs=**	**125,00**	
valve type	globe valve		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

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0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV90014** Project No.: K70101
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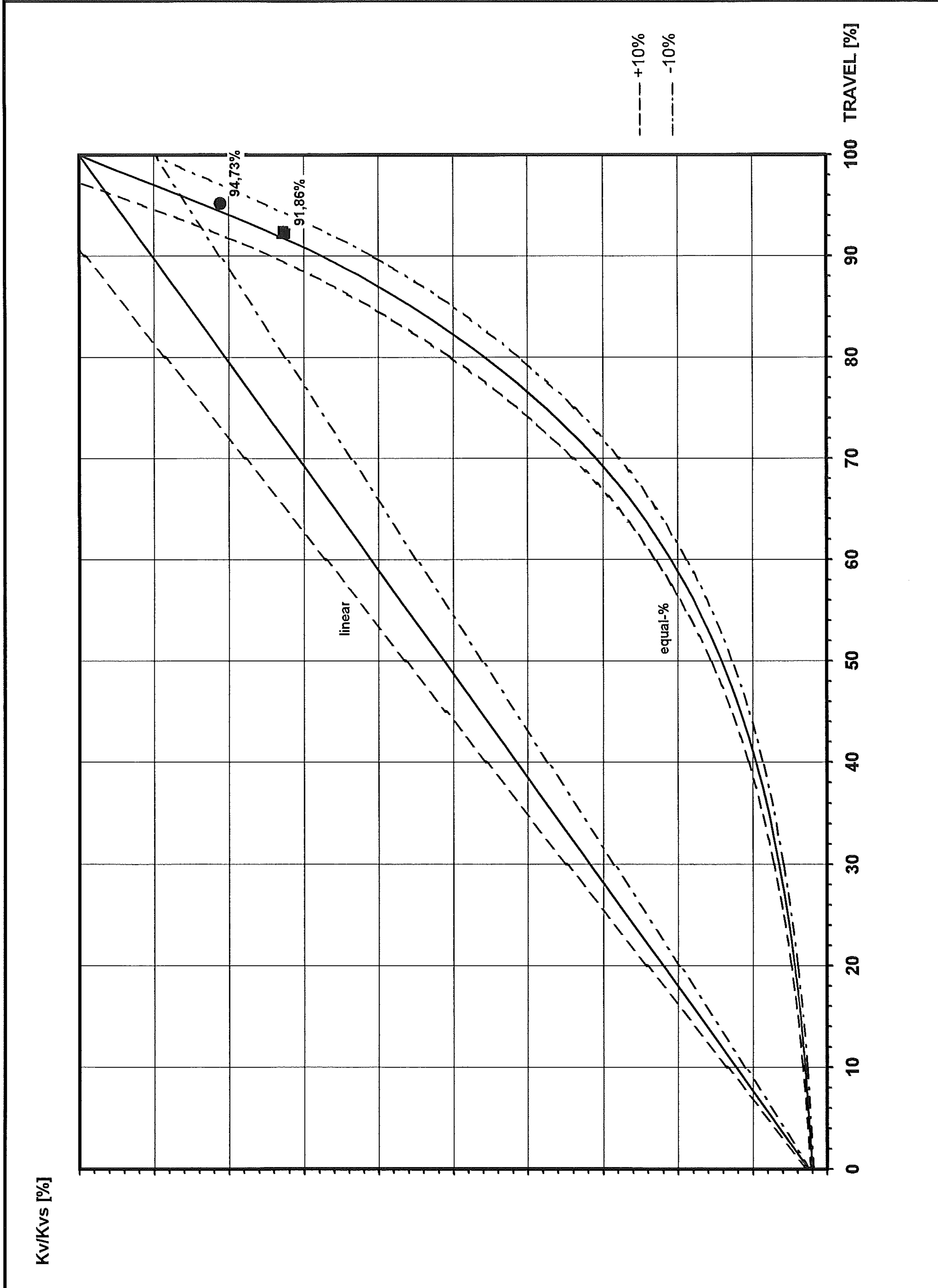

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

AIR LIQUIDE	**Specification** Calculation of Control (Butterfly-)Valves	TAG - No.: **HV90015** Project-No.: K70101
Air Liquide AGS GmbH	Project: **ASU No. 9 KOSICE**	Page: of:

calculation of Kv-value	pressure gradient	liquids flow (m³/h)	liquids flow (kg/h)	gases flow (m³/h)	gases flow (kg/h)	steam flow (kg/h)
	subcritical $p2 > \frac{p1}{2}$ $\Delta p < \frac{p1}{2}$	$k_v = Q^* \sqrt{\frac{\rho_1}{1000^* \Delta p}}$	$k_v = \frac{G}{\sqrt{1000^* \rho_1 ^* \Delta p}}$	$k_v = \frac{Q_N}{514}\sqrt{\frac{\rho_N {}^* T1}{\Delta p^* p2}}$	$k_v = \frac{G}{514}\sqrt{\frac{T1}{\rho_N {}^* \Delta p^* p2}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{V2}{\Delta p}}$
	supercritical $p2 < \frac{p1}{2}$ $\Delta p > \frac{p1}{2}$			$k_v = \frac{Q_N}{257 p1}\sqrt{\rho_N {}^* T1}$	$k_v = \frac{G}{257 p1}\sqrt{\frac{T1}{\rho_N}}$	$k_v = \frac{G}{\sqrt{1000}}\sqrt{\frac{2V^*}{p1}}$

		SERVICE CONDITIONS		
medium		argon		
state		liquid		
standard density		1,7840 kg/m³		
		case 1	**case 2**	**case 3**
volume flow	**Q [m³/h]**	26,24	72,15	72,15
standard flow (0°C, 1,013 bar)	**Q_N [Nm³/h]**	20000,00	55000,00	55000,00
charge pressure (abs.)	**p1 [bar]**	1,740	5,00	6,00
discharge pressure (abs.)	**p2 [bar]**	1,013	1,01	1,01
pressure loss	**Δp [bar]**	0,727	3,99	4,99
mass flow	**G [kg/h]**	35680,00	98120,00	98120,00
medium density	**ρ_1 [kg/m³]**	1360,000	1360,00	1360,00
absolute temp. (inlet side)	**T1 [K]**	92,60	92,60	92,60
spec. volume at p2 and t1	**V2 [m³/kg]**	0,19	0,19	0,19
spec. volume at p1/2 and t1	**V* [m³/kg]**	0,22	0,08	0,06
		RESULTS		
		case 1	**case 2**	**case 3**
pressure gradient		subcritical	supercritical	supercritical
flash (%)				
Kv_flash				
Kv_liquid		35,88	42,14	37,68
Kv_tot		35,88	42,14	37,68
travel (%) (first give Kvs-value!)		92,83	96,94	94,08
selected Kvs-value		**Kvs=**	**47,50**	
valve type		globe valve		

Travel indication only depends on valves with equal-% characteristic.

STANDARD DENSITIES OF COMMON GASES

gas	chemical symbol	density ρ_N kg/m³
helium	He	0,17848
argon	Ar	1,784
hydrogen	H_2	0,08988
nitrogen	N_2	1,2504
oxigen	O_2	1,429
air		1,293
carbon monoxid	CO	1,2505
carbon dioxide	CO_2	1,977
sulfur dioxide	SO_2	2,931
ammonia	NH_4	0,7718
methane	CH_4	0,7175
ethyne (acetylene)	C_2H_2	1,1715
ethene (ethylene)	C_2H_4	1,2611
ethane	C_2H_6	1,355

Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change
0	19.01.2005	Möller	Eichler	Initial Version					

AIR LIQUIDE	**Specification** Control Valve Characteristic	TAG - No.: **HV90015** Project No.: K70101
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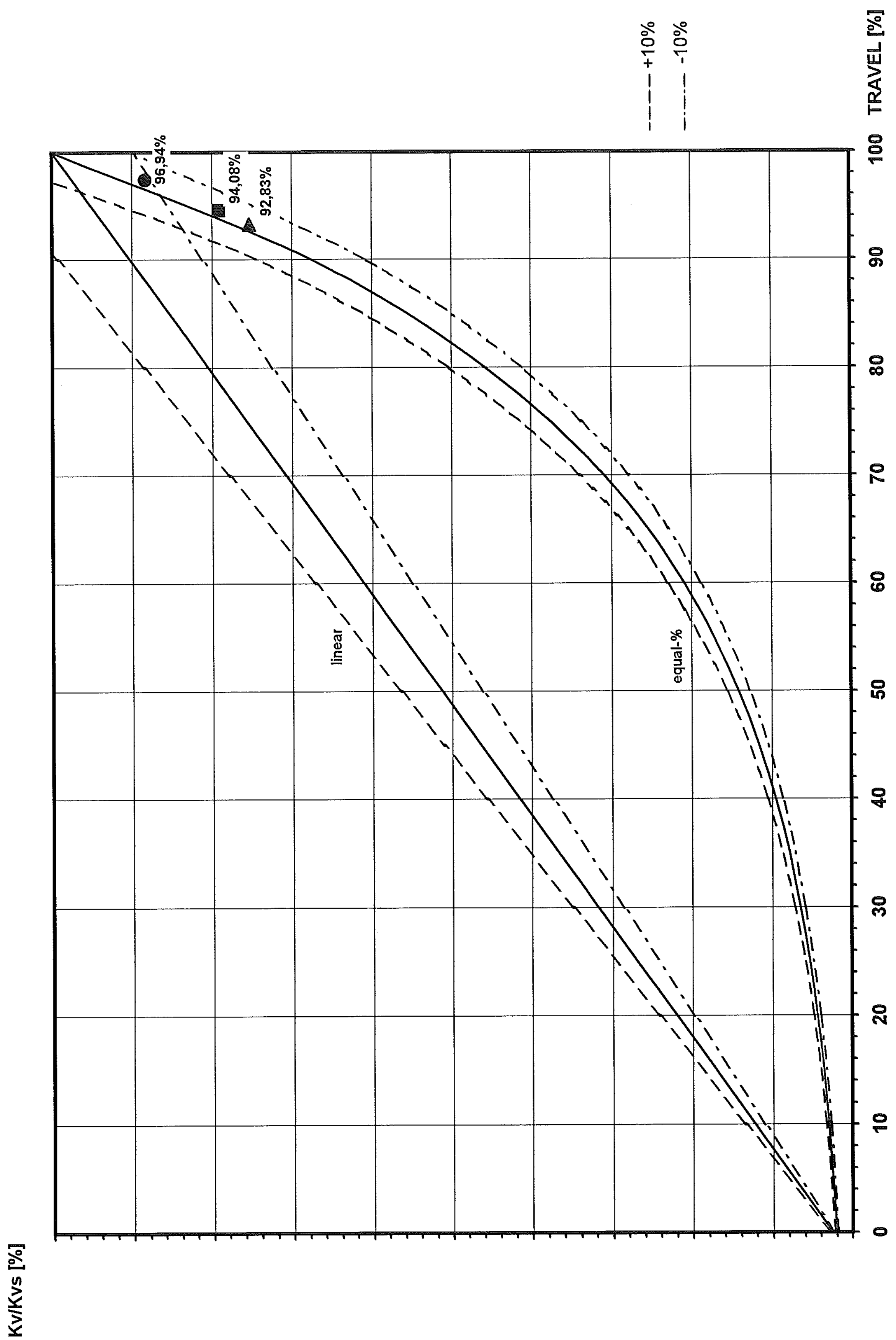

0	19.01.2005	Möller	Eichler	Initial Version					
Rev.	Date	Name	Checked	Change	Rev.	Date	Name	Checked	Change

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