Germanischer Lloyd

Richtlinien
über
die Auslegung, Ausrüstung und Prüfung
geschlossener Brennstoff-Überlaufsysteme

Regulations
for
Construction, Equipment and Testing of
Closed Fuel Oil Overflow Systems

June 1990

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Regulations
for
Construction, Equipment and Testing of
Closed Fuel Oil Overflow Systems

A. General

The construction, equipment and testing of closed fuel oil overflow systems must be in accordance with these regulations.

1. Other Rules and Regulations simultaneously applicable

Beside these regulations the following Rules of Germanischer Lloyd for the Classification and Construction of Seagoing Steel Vessels also apply:

- Chapter 2, Section 12 - for the storage tanks
- Chapter 3, Section 11 - for the pipelines and valves
- Chapter 4 - for the electrical equipment

2. Definition of Designations

2.1 Closed Overflow System

A closed overflow system is a system which is constructed and equipped so that during fuel oil bunkering the allowable design pressure of the storage tanks cannot be exceeded.

A closed overflow system consists of all pipe lines (bunker lines, overflow line, filling lines of the tanks), storage tanks and overflow tanks together with their associated valves and fittings as well as all control and measuring devices.

2.2 Overflow Line

The overflow line is the part of the closed overflow system through which the fuel oil is diverted to the overflow tank. The overflow line may be arranged before or after the storage tanks.

2.3 Design Pressure

The design pressure for the storage tanks is the test pressure head according to the Rules of Germanischen Lloyd, Chapter 2, Section 12. For overflow systems according to 3.1 the dynamic pressure losses are to be considered in addition.

2.4 Bunker Station

The bunker station is the stand from where the bunkering operation is centrally monitored and constrolled.

3. Grouping of Closed Fuel Oil Overflow Systems

Within the scope of these regulations closed fuel oil systems are subdivided into three groups.

3.1 Systems of Group I

Systems of Groupe I (Fig. 1) are systems having monitoring devices whereby excess pressure in the storage tanks is prevented by reduction of the bunker rate.

Overflow is effected by means of an overflow line between storage tank and overflow tank.

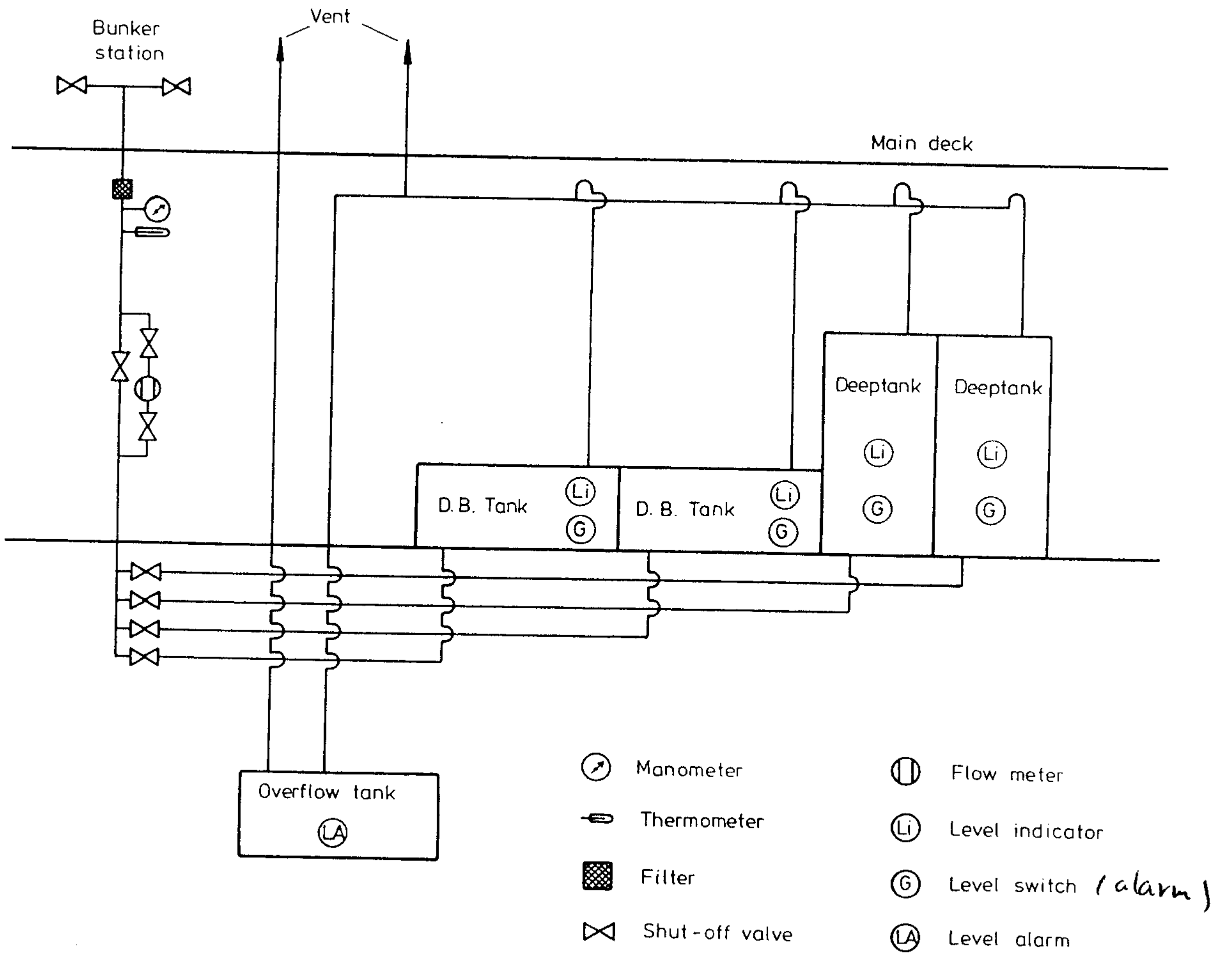

Fig. 1 Fuel Oil Overflow System of Group I

3.1.1 The storage tanks may only be filled by the allowable bunker rate up to a maximum level defined by the shipyard.

3.1.2 On reaching of the maximum level the tanks are then filled by the intended topping-up rate. Adherence to the topping-up rate is to be monitored by the flow meter.

3.1.3 If the overflow line is designed for the intended maximum bunker rate, the requirement according to 3.1.1 may be dispensed with.

3.2 Systems of Group II

Systems of Group II (Fig.2) are systems having pressure limiting devices [1] whereby pressures in excess of the design pressures of the storage tanks are prevented by means of an intermediate overflow valve.

Overflow is effected by means of an overflow line and overflow valve between bunker line and overflow tank.

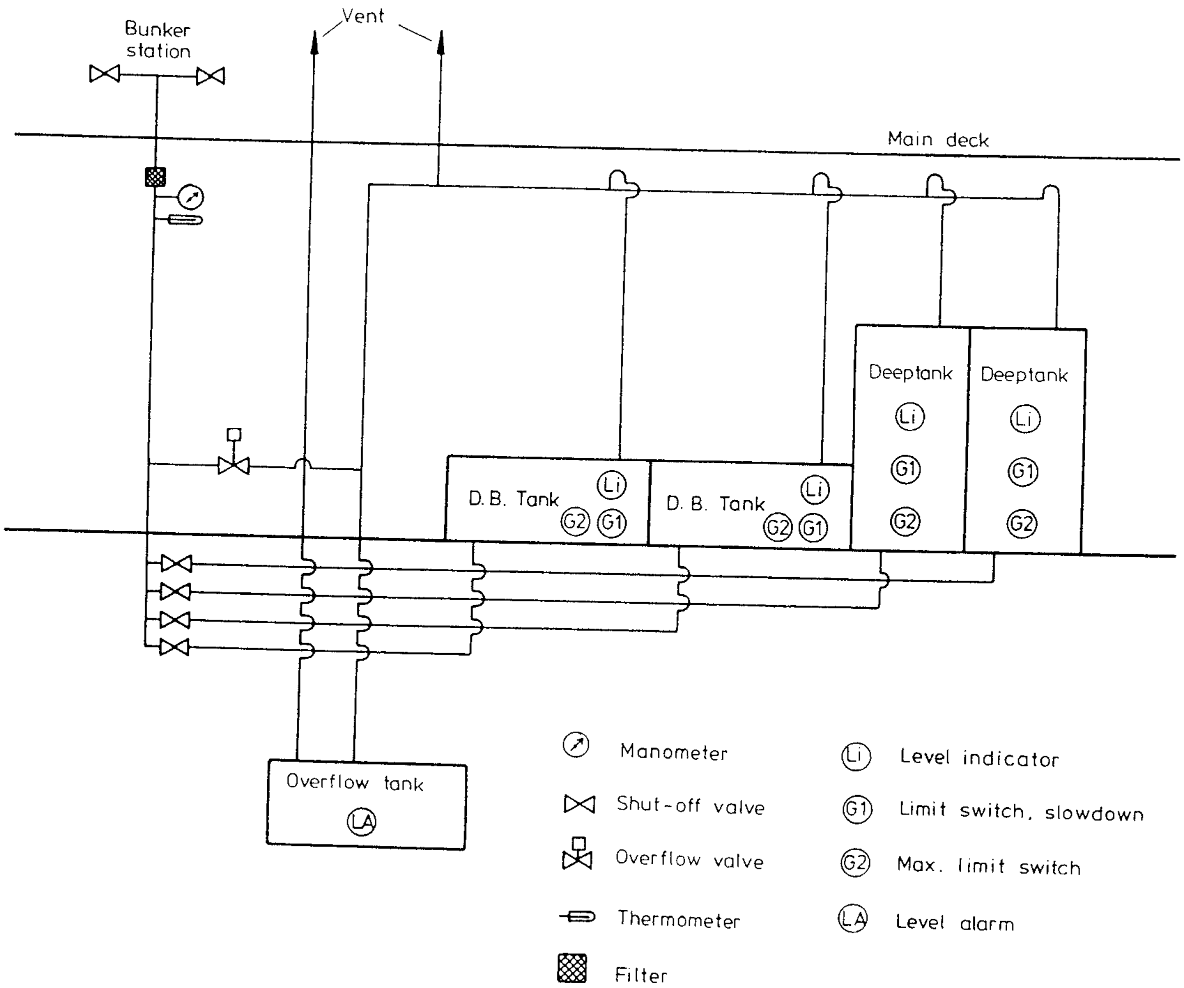

Fig. 2 Fuel Oil Overflow System of Group II

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1) Overflow valves or other suitable devices can be applied as pressure limiting devices. In the following the designation overflow valves is used.

3.2.1 The overflow valve may be direct acting or controlled by auxiliary energy.

3.2.2 Each storage tank is to be fitted with two independently actuating limit switches.

3.2.3 The storage tanks may be filled by the maximum allowable bunker rate up to the first level (limit switch slowdown). Topping-up of the tanks is to be carried out at a reduced bunker rate.

3.2.4 The maximum allowable filling level of each storage tank is monitored by a second limit switch (max. alarm). It will signal that the inlet valve is to be closed.

3.2.5 If overflow valves are of a type controlled by auxiliary energy they will be opened by the limit switch. "max. alarm" when the maximum allowable filling level is exceeded.

3.3 Systems of Group III

Systems of Group III (Fig. 3) are systems equipped with pressure limiting devices and automatic control of the tank valves, whereby pressures in excess of the design pressures of the storage tanks are prevented by automatic limitation of the filling levels.

Overflow is effected by an overflow line and overflow valve between bunker line and overflow tank.

3.3.1 Each storage tank is to be equipped with two independently actuating limit switches by which control of the tank inlet valves and the overflow valve is effected.

3.3.2 The storage tanks may be filled with the maximum allowable bunker rate up to the first limit (limit switch slowdown-alarm).

By actuation of the limit switch slowdown-alarm the inlet valve of the tank concerned is closed and locked. When the last tank to be filled has reached that limit level, the overflow valve is pened simultaneously. Fuel oil bunkering is then to be discontinued.

3.3.3 The system is switched to topping up. This effects closing of the overflow valve and opening of the inlet valves of the tanks to be filled. The storage tanks can then be further filled by the topping-up rate.

By means of the second limit switch (max. alarm) the inlet valves of the individual tanks are closed and locked. When the last tank to be filled has reached that limit level, the overflow valve is opened simultaneously.

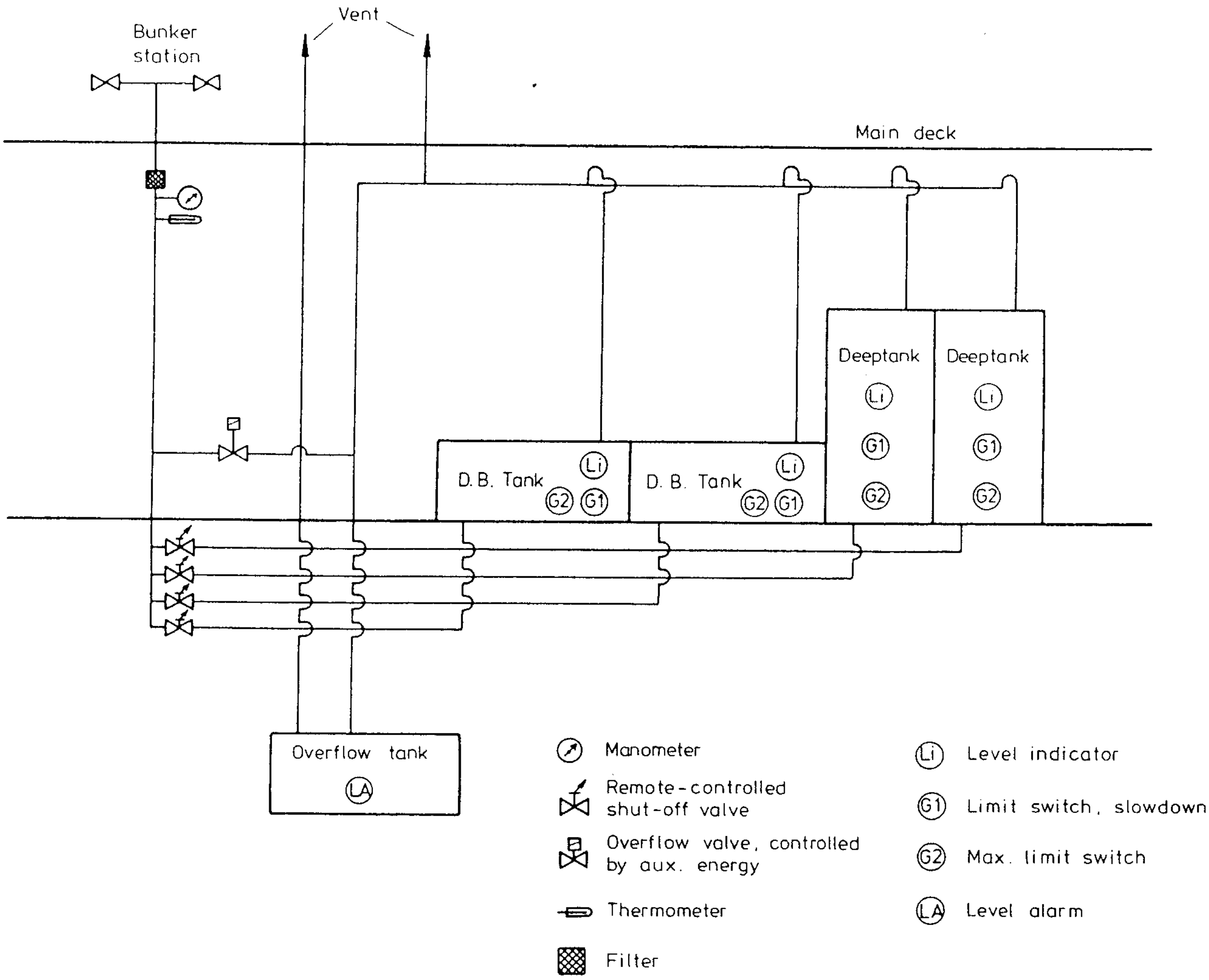

Fig. 3 Fuel Oil Overflow System of Group III

3.3.4 On completion of fuel oil bunkering the overflow system may be switched to normal operation. By that the tank valves are unlocked, the overflow valve is closed and the limit switches switched to inactive.

3.3.5 Inlet valves of storage tanks which are not to be filled, are to be closed and locked prior to fuel oil bunkering and the corresponding limit switches to be switched to the position "inactive".

4. Documents for Approval

The following documents are to be submitted to Germanischer Lloyd in triplicate for approval.

4.1 For Systems of Groups I, II and III

- Tank plan with details on the design pressures of the tanks
- Schematic drawing of the overflow system
- Pressure loss calculation for the overflow line
- Technical data on level indicating arrangement and limit switches
- List of pipes and valves
- Electrical wiring diagrams
- Bunkering instructions

4.1.1 Additionally for Systems of Group I

- Dimensioned isometric drawing of the overflow line
- Technical data of the flow meter

4.1.2 Additionally for Systems of Group II

- Technical data of the overflow valves
- In the case of using direct acting overflow valves:

  Dimensioned isometric drawing of bunker line, overflow line and filling lines as well as a pressure loss calculation for the filling lines of the tanks up to the overflow valve.

4.1.3 Additionally for Systems of Group III

- Technical data of the overflow valves and the remote controlled tank valves and their wiring diagrams.

B. Construction and Equipment of the Systems

1. Systems of Group I

1.1 Construction

1.1.1 It is to proved by calculation that the total resistance through the overflow line does not exceed the design pressure of the tanks connected to the system during overflow, taking the topping-up rate into consideration.

The calculation of the overflow line rate is to be carried out for the topping-up rate according to the Annex.

1.1.2 The level limits in the tanks are to be so arranged that the remaining volume between the level and the tank top is sufficient to take up the volume flow until the bunker rate is reduced [1].

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1) For guidance period of approx. 5 minutes can be assumed for the time needed until the bunker rate is reduced.

1.2 Equipment

1.2.1 Bunker Line

The bunker line is to be fitted with filter, pressure gauge, thermometer, and flow meter.

1.2.2 Storage Tanks

The storage tanks are to be fitted with level indicating arrangements. Each tank is to be provided with a limit switch.

1.2.3 Overflow Line

If necessary, the overflow line is to be provided with heat tracing and insulation.

1.2.4 Bunker Station

The following equipment is to be arranged in the bunker station:

- Filling level indicators and level alarms of the storage tanks
- End position indicators for remote controlled tank valves if provided
- Indicator for the flow meter
- Level alarm of the overflow tank
- Bunkering instructions.

2. Systems of Group II

2.1 Construction

2.1.1 The overflow line is to be so dimensioned as to allow discharging of the maximum allowable bunker rate to the overflow tank with opened overflow valve without excess pressure increase in the tanks.

2.1.2 The set pressure of direct acting overflow valves is to be determined as follows:

$$p_o = (H_1 - H_2) \cdot g \cdot \rho_w \quad [N/m^2]$$

p_o	$[N/m^2]$	Set pressure of the overflow valve
H_1	[m]	Height of test pressure of the tanks above base
H_2	[m]	Fitting position of the overflow valve above base
g	$[m/s^2]$	Acceleration due to gravity
ρ_w	$[kg/m^3]$	Density of water

If the tanks have been constructed for different test pressure values, the lowest test pressure value is to be set for H_1.

2.1.3 Overflow valves with auxiliary energy must open automatically at failure of energy supply and be equipped with a means for manual operation.

2.1.4 When using overflow valves with auxiliary energy, the limit switch (max. alarm) is to be so adjusted that the overflow valve will open before the design pressure of the particular tank is reached.

2.2 Equipment

2.2.1 Bunker Line

The bunker line is to be fitted with filter, pressure gauge, and thermometer.

2.2.2 Storage Tanks

The storage tanks are to be fitted with level indicating arrangements. Two independently actuating limit switches are to be installed in each tank.

2.2.3 Overflow Line

The overflow line is to be provided with an overflow valve.

2.2.4 Bunker Station

The following equipment is to be arranged in the bunker station:

- Filling level indicators and level alarms for the storage tanks
- End position indicators for remote controlled tank valves if provided
- Level alarm for the overflow tank
- Pressure gauge for the bunker line if a direct acting overflow valve is arranged
- End position indicator for the overflow valve
- Bunkering instructions

3. Systems of Group III

3.1 Construction

3.1.1 The filling limit levels are to be determined by consideration of bunker rate and topping-up rate respectively, volume and shape of the tanks, closing time of the tank inlet valves of the tanks as well as opening time of the overflow valve [1].

3.1.2 Overflow valves with auxiliary energy must open automatically at failure of energy supply and be fitted with means for manual operation.

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1) Guidance for limit levels in the tanks:
Limit level 1: approx. 80 - 90 % filling level
Limit level 2: approx. 95 - 98 % filling level

3.1.3 The overflow line is to be so dimensioned as to allow the maximum allowable bunker rate to be discharged to the overflow tank with open overflow valve without excess pressure increase occuring in the tanks.

3.1.4 The air pipes of the storage tanks are to be so dimensioned and arranged as to preclude pressure increase in the tanks affecting the measuring instruments.

3.2 Equipment

3.2.1 Bunker Line

The bunker line is to be fitted with filter, pressure gauge, and thermometer.

3.2.2 Storage Tanks

The storage tanks are to be fitted with level indicating arrangements. Two independently actuating limit switches are to be installed in each tank.

3.2.3 Overflow Line

The overflow line is to be provided with an overflow valve.

3.2.4 Bunker Station

The following equipment is to be arranged in the bunker station:

- Filling level indicators and level alarms for the storage tanks
- End position indicators for remote controlled tank valves and overflow valves
- Level alarm for the overflow tank
- Bunkering instructions.

4. Overflow Tanks

Overflow Tanks are to be so dimensioned that they can tak up the volume flow entered until bunkering is stopped. Overflow tanks are to be equipped with level alarms at approx. $^1/_3$ full.

C. Testing

1. Initial Operation of the System

1.1 After completion and prior to the first operation every fuel oil overflow system is to be tested.

The following equipment and instruments are to be tested and adjusted:

- Safety devices
- Pressure indicators and their drives

- Alarm and locking devices
- Indicating and measuring instruments.

1.2 A GL-Surveyor is to be present during the first operation of the system.

2. Periodical Surveys

On the occasion of each periodical survey the functioning of the overflow system is to be tested.

ANNEX

Calculation of the Overflow Line

Formula Characters

Δp	[Pa]	Loss of pressure
λ	[-]	Coefficient of pipe friction [1]
L	[m]	Length of the straight pipe
d_i	[m]	Inside pipe diameter
d_a	[m]	Outside pipe diameter
$d_{gl.}$	[m]	Equivalent pipe diameter
w	[m/s]	Velocity of flow
ρ	[kg/m³]	Density
ζ	[-]	Resistance coefficient [2]
$h_{geod.}$	[m]	Geodetic height
V	[m³/s]	Volume flow
A	[m²]	Cross section of pipe
A_d	[m²]	Cross section of pipe running full
U	[m]	Wetted circumference
g	[m/s²]	Acceleration due to gravity
Re	[-]	Reynolds' number
$Re_{Kr.}$	[-]	Critical Reynolds' number (2320)
ν	[m²/s]	Kinematic viscosity
c	[-]	Correction factor
s	[mm]	Thickness of pipe
Δs	[mm]	Tolerances of wall thickness

1) In the systems handled in these regulations laminar flow ($Re < Re_{Kr.}$) can be assumed. Thus the coefficient of pipe friction is a function of the Reynolds' number.

2) The Zeta values needed for the calculation are to be taken from recognized standards or publications.

1. Calculation of the overflow line

The overflow line is to be so laid out that the dynamic and static pressure losses due to flow through the line with the topping-up rate will not exceed the design pressure of the storage tanks.

This means that

$$\Delta p_{ges.} = \Delta p_{dyn} + \Delta p_{stat.} < \text{Design pressure}$$

2. Calculation of the Pressure Losses in the Overflow Line

The calculation of the pressure losses in the overflow line is made in consideration of the following parameters:

- Max. allowable viscosity of the fuel oil at bunkering
- Density [1] of the fuel oil related to the temperature at bunkering.

2.1 Calculation of the dynamical Pressure Losses

The loss of pressure in a pipeline results from the resistance behaviour of the straight pipe lenghts and their fittings for changes in direction, cross section and flow as well as from their components (valves, sight glasses) and can be determined as follows:

$$\Delta p = \lambda \cdot \frac{L}{d_i} \cdot \frac{\rho}{2} \cdot w^2$$ for the straight pipe length [1]

$$\Delta p = \zeta \cdot \frac{\rho}{2} \cdot w^2$$ for the fittings [2]

From formulae [1] and [2] results the dynamical pressure loss of a pipe section, since:

$$\Delta p_{dyn} = \Sigma \left[\left(\lambda \cdot \frac{L}{d_n} + \Sigma \zeta_n \right) \frac{\rho}{2} \cdot w_n^2 \right]$$ [3]

where:

$\lambda \cdot \frac{L}{d_n}$ is the resistance coefficient for the straight pipe lenght of inside diameters $d_1 \ldots d_n$

and

$\Sigma \zeta_n$ is the sum of the individual resistance coefficients for fittings and components in pipe
sections of flow rate $w_1 \ldots w_n$

---

1) In the calculation the density is to be given with min. 1000 (kg/m³).

2.2 Correction Factor and equivalent Diameter

The allowable tolerances for pipes given in the standards are to be taken into consideration by means of a correction factor.

This can be approximately calculated as follows:

$$c = \left[\frac{1}{1 - \frac{\Delta s}{s} \cdot \left(\frac{d_a}{d_i} - 1 \right)} \right]^5 \qquad [4]$$

Equation [4] put in equation [3], results in

$$\Delta p_{dyn} = \Sigma \left[\left(\lambda \cdot \frac{L}{d_n} + \Sigma \zeta_n \right) c_n \cdot \frac{\rho}{2} \cdot w_n^2 \right] \qquad [5]$$

where c_n are the correction values for d_1 ... d_n pipe diameters.

Equation [1] also applies to non-circular cross sections if instead of the inside diameter d_i the equivalent diameter $d_{gl.}$ is put in:

$$d_{gl.} = \frac{4 \cdot A_d}{U} \qquad [6]$$

2.2.1 Pressure Losses for Pipes connected in parallel

If two or more overflow pipe lines are lead from a storage tank to the collecting manifold, the following applies:

- same pressure loss

$$\Delta p_{dyn.} = \text{const.}$$

- single volume flows add up to the total volume flow

$$V = V_1 + V_2 + \ldots V_n$$

The solution of the individual equations [3] can only be found by iteration, since $\lambda = f\,(R_e)$ und $R_e = f\,(w)$ ist.

2.2.2 Pressure Losses for Pipes connected in Series

Analogous to 2.1.1 the presure losses for the individual pipes are to be determined according to equation [3].

The pressure loss of all pipes results from the sum of all individual pressure losses:

$$\Delta p_{dyn} = \Delta p_{dyn1} + \Delta p_{dyn2} + \dots \Delta p_{dynn}$$

3. Calculation of the Statical Pressure Losses

The statical pressure loss results from the geodetic heights of the overflow pipe lines, measured between tank top and overflow summit (peak) of the pipes. This is to be determined as follows:

$$\Delta p_{stat.} = h_{geod.} \cdot g \cdot \rho \qquad [7]$$

GERMANISCHER LLOYD 1867

HV-HAMBURG

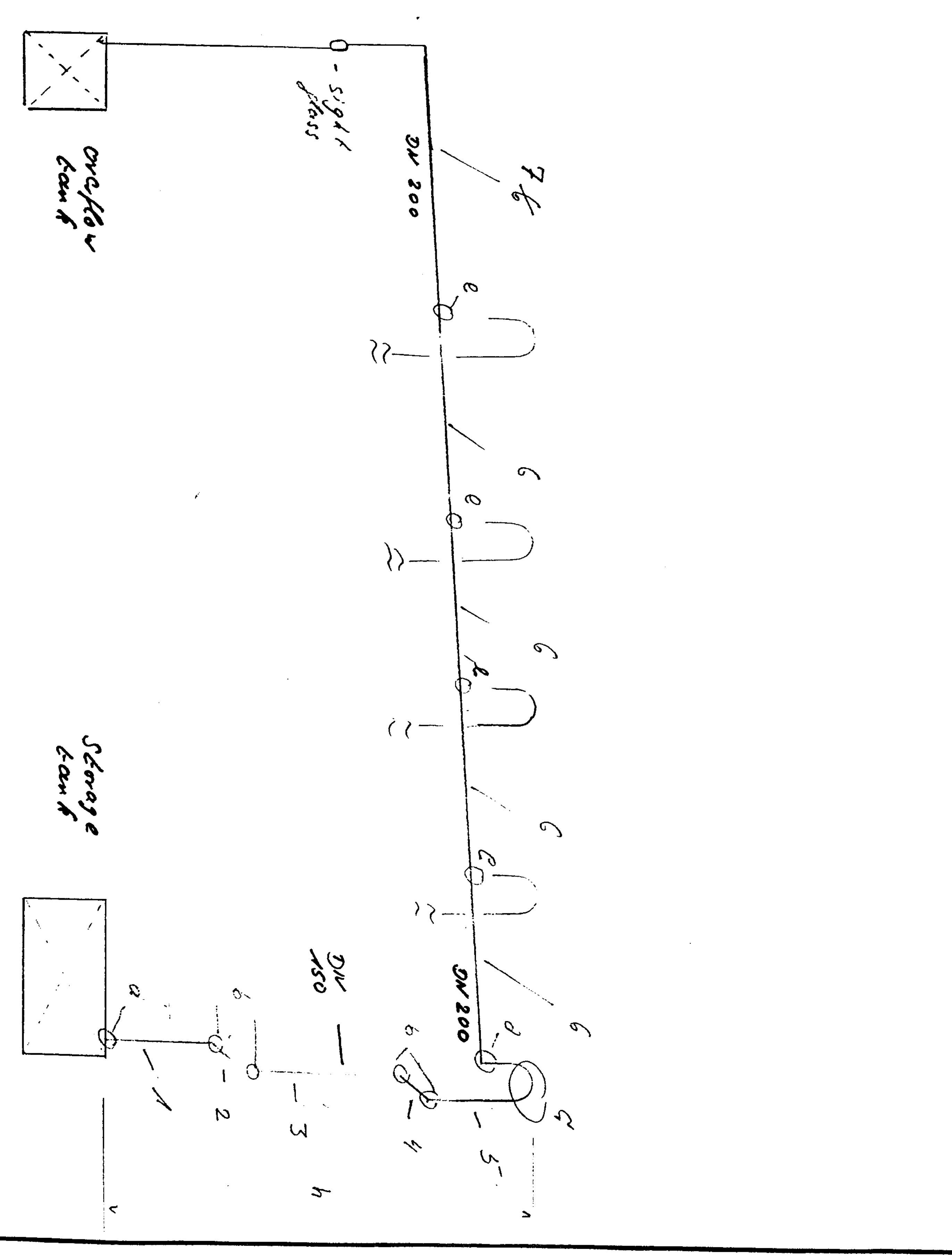
PROJEKT:

FOR INFORMATION

BEARBEITER:

DATUM:

SEITE: 1



GERMANISCHER LLOYD 1867

HV-HAMBURG

PROJEKT:

FOR INFORMATION

BEARBEITER:

DATUM:

SEITE: 2

Topping-Rate : 80 m^3/h $\frac{80}{3600}$

$\dot{w} = 0{,}0222$ m/sec

Fuel : IF 380

at 45 °C : $\nu = 510 \cdot 10^{-6}$ m^2/sec

Bunkering during Topping-Procedure : One by One !

$DN\,150 = d - 2 \times s = 168{,}3 - 2 \times 7{,}1$

$d_{150} = 154{,}1\,mm = 0{,}1541\,m$

$DN\,200 = 219{,}1 - 2 \times 8{,}2$

$d_{200} = 202{,}7\,mm = 0{,}2027\,m$

$A = \frac{d^2 \cdot \pi}{4} = \frac{0{,}1541^2 \cdot \pi}{4}$

$A_{150} = 0{,}0187\,m^2$

$A_{200} = \frac{0{,}2027 \cdot \pi}{4} =$

$A_{200} = 0{,}0323\,m^2$

$W = \frac{\dot{w}}{A}$

$W_{150} = \frac{0{,}0222}{0{,}0187} = 1{,}1872\,m/sec$

$W_{200} = \frac{0{,}0222}{0{,}0323} = 0{,}6873\,m/sec$

GERMANISCHER LLOYD 1867
HV-HAMBURG

PROJEKT:

FOR INFORMATION

BEARBEITER:

DATUM:

SEITE: 3

$$Re = \frac{w \cdot d}{\nu}$$

$$Re_{150} = \frac{w_{150} \cdot d_{150}}{\nu} = \frac{1,1872 \cdot 0,1541}{510 \cdot 10^{-6}} = \underline{358,72}$$

$$Re_{200} = \frac{0,6873 \cdot 0,2027}{510 \cdot 10^{-6}} = \underline{273,17}$$

$$\lambda = \frac{64}{Re}$$

$$\lambda_{150} = \frac{64}{Re_{150}} = \frac{64}{358,72} = \underline{0,1784}$$

$$\lambda_{200} = \frac{64}{Re_{200}} = \frac{64}{273,17} = \underline{0,2343}$$

lenght: h = 6,75 m

l 1	= 1,5 m	DN 150		l 6	= 12,5 m	
2	= 0,5 m	"		↳ 4x	= 50,0 m	
3	= 2,0 m	"		l 7	= 20,0 m	
4	= 0,5 m	"				
5	= 2,5 m	"				
Σl	= 7,0 m	DN 150		Σl	= 70 m	DN 200

Resistance coefficient ζ zeta

a = inlet opening overflow pipe		≈ 1,05	→	1,05
b = 4 bends 45°	R = 2 d	≈ 0,15	→	0,6
c = 2 bends 90°	R = 1,5 d	≈ 0,30	→	0,6
d = 1 bend 90°	R = 2 d	≈ 0,25	–	0,25
e = T-pieces DN 200	4x	≈ 0,30	→	1,2

$\Sigma \zeta$ DN 150 ⇒ $\underline{2,50}$

$\Sigma \zeta$ DN 200 ⇒ 1,20

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$$\Delta p_{dyn} = \left(\lambda \cdot \frac{L}{d_i} + \Sigma \xi\right) \cdot \frac{\rho}{2} \cdot w^2$$

$$\Delta p_{150} = \left(0{,}1784 \cdot \frac{7}{0{,}1541} + 2{,}50\right) \cdot \frac{1000}{2} \cdot 1{,}1872^2$$

$$= \underline{\underline{7.472{,}8 \ Pa}}$$

$$\Delta p_{200} = \left(0{,}2343 \cdot \frac{70}{0{,}2027} + 1{,}20\right) \cdot \frac{1000}{2} \cdot 0{,}6873^2$$

$$= \underline{\underline{19.394{,}2 \ Pa}}$$

$$p_{stat} = h \cdot g \cdot \rho$$

$$= 6{,}75 \cdot 9{,}81 \cdot 1000$$

$$= \underline{\underline{66.217{,}5 \ Pa}}$$

$$\Delta p = \Sigma \Delta p_{dyn} + \Delta p_{stat}$$

$$= 7.472{,}8 + 19.394{,}2 + 66.217{,}5$$

$$= \underline{\underline{93.084{,}5 \ Pa}}$$

Tank design pressure $\geq p_{design}$

$$p_{design} \geq \Delta p \cdot 1{,}1$$

$$\geq \underline{\underline{102\,393 \ Pa}}$$

The calculated pressure loss shall be less than the design pressure of the tank.

ANNEX
FOR INFORMATION
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A_d	[m²]	Cross section of pipe running full
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Re	[-]	Reynolds' number
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ν	[m²/s]	Kinematic viscosity
c	[-]	Correction factor
s	[mm]	Thickness of pipe
Δs	[mm]	Tolerances of wall thickness

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2) The Zeta values needed for the calculation are to be taken from recognized standards or publications.

For Information only

BUNKERING INSTRUCTIONS

max Bunkering rate	-	200m3/h
max Topping up rate	-	80m3/h
max Viscosity	-	380 cSt
min Bunkertemperatur	-	50°C

Valves for the HFO tanks to be open, start bunkering with a rate of 200 m3/h .
The fuel oil level in the tanks is to be watched by the crew
When reaching the alarmpoint 85% the according tank is to be closed. Before the last tank is closed bunkering is to be stopped. After having filled all tanks to 85% capacity, start topping up the HFO tanks one by one with a rate of 80m3/h. After topping up the according tank is to be closed.