STUDY OF TURBINE DESIGN, CONTROL SYSTEMS AND POWER PRODUCTION FOR SANTO ANTÕNIO PROJECT

1. **CHOICE BETWEEN KAPLAN AND BULB TURBINES.**

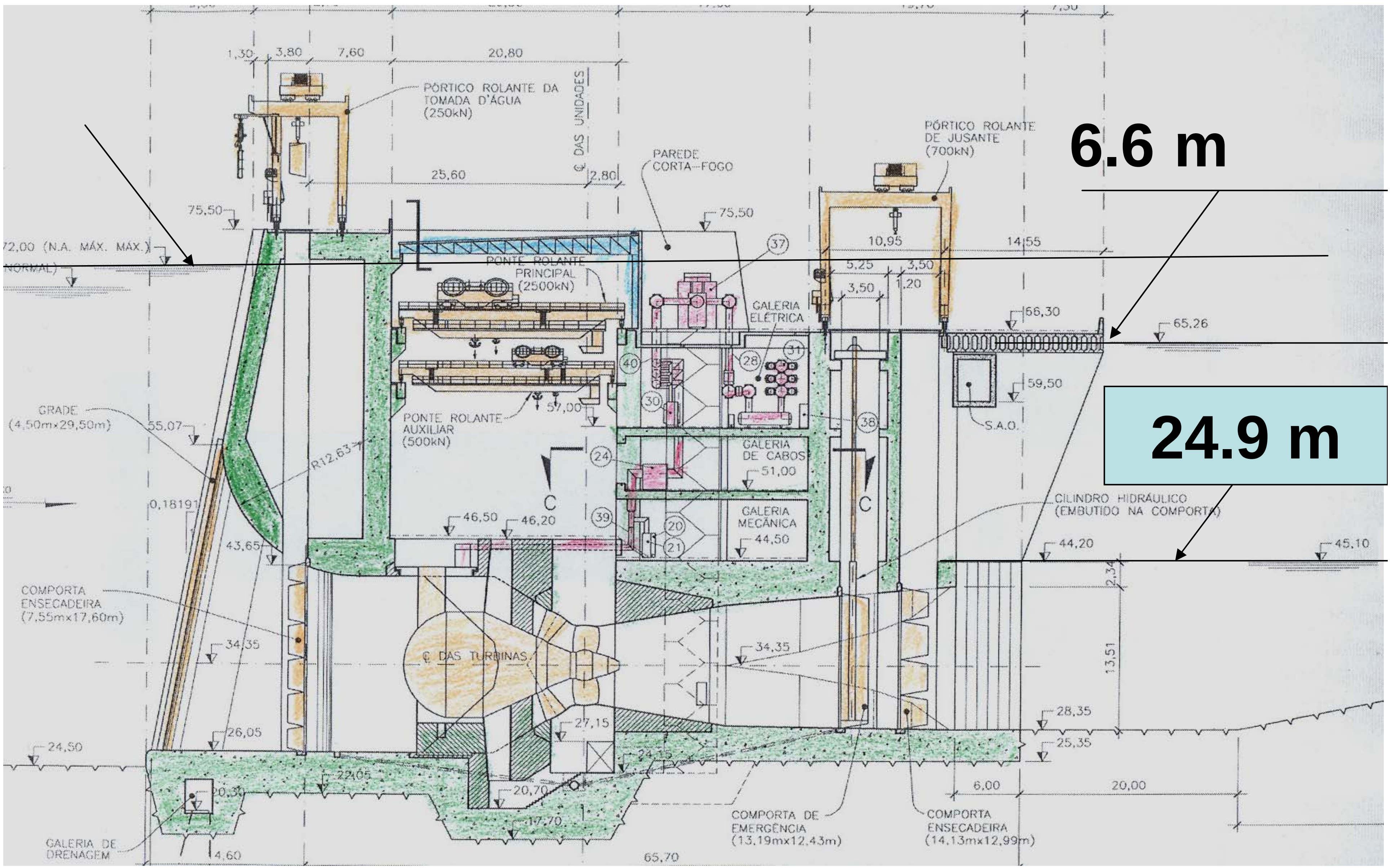
2. **OPERATION LIMITATIONS BECAUSE OF LARGE VARIATIONS IN FLOW AND WATER LEVEL.**

3. **HYDRAULIC FORCES FROM TURBINES ON POWER HOUSE AND THRUST BEARINGS.**

4. **POSSIBLE SAND EROSION PROBLEMS.**

5. **POSSIBLE CONTROL PROBLEMS OF TURBINES.**

6. **MATERIAL QUALITY AND STANDARDS, BRAZILIAN PRODUCTION**

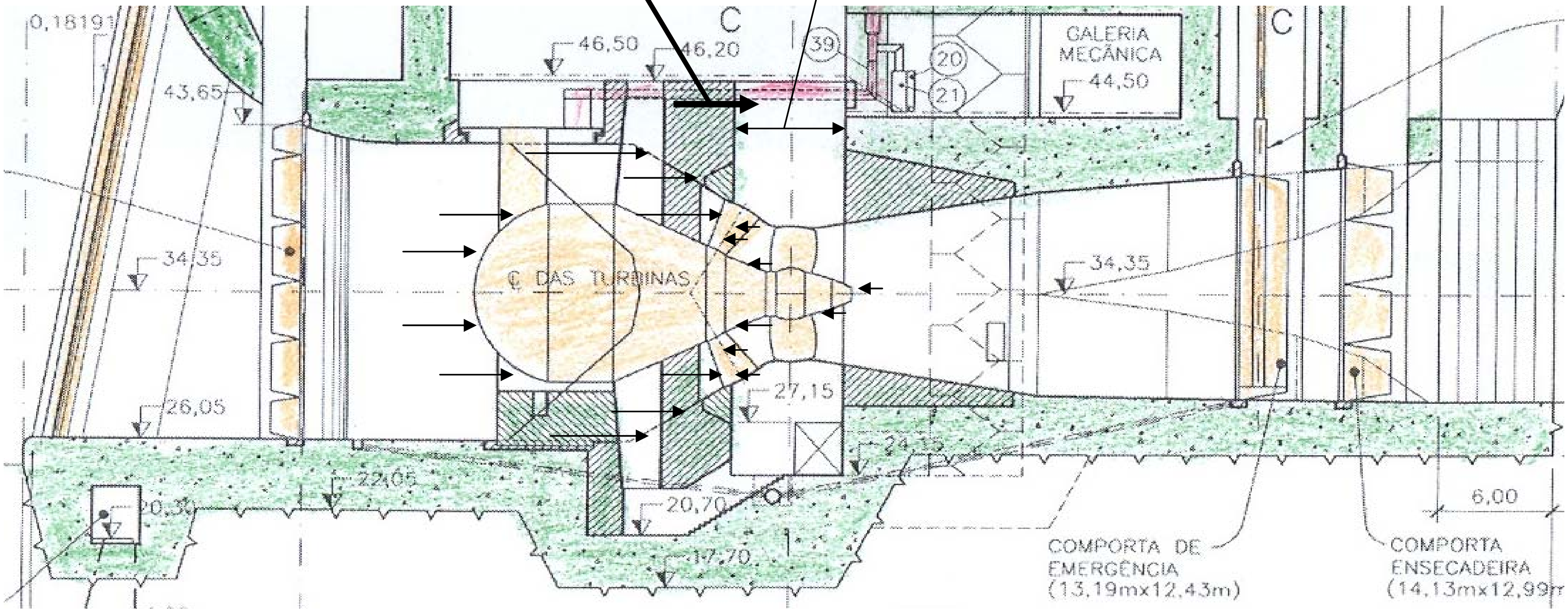


6.6 m
24.9 m
PÓRTICO ROLANTE DA TOMADA D'ÁGUA (250kN)
PÓRTICO ROLANTE DE JUSANTE (700kN)
PAREDE CORTA-FOGO
PONTE ROLANTE PRINCIPAL (2500kN)
PONTE ROLANTE AUXILIAR (500kN)
GALERIA ELÉTRICA
GALERIA DE CABOS
GALERIA MECÂNICA
GRADE (4,50m×29,50m)
COMPORTA ENSECADEIRA (7,55m×17,60m)
CILINDRO HIDRÁULICO (EMBUTIDO NA COMPORTA)
COMPORTA DE EMERGÊNCIA (13,19m×12,43m)
COMPORTA ENSECADEIRA (14,13m×12,99m)
GALERIA DE DRENAGEM
S.A.O.
℄ DAS TURBINAS
℄ DAS UNIDADES

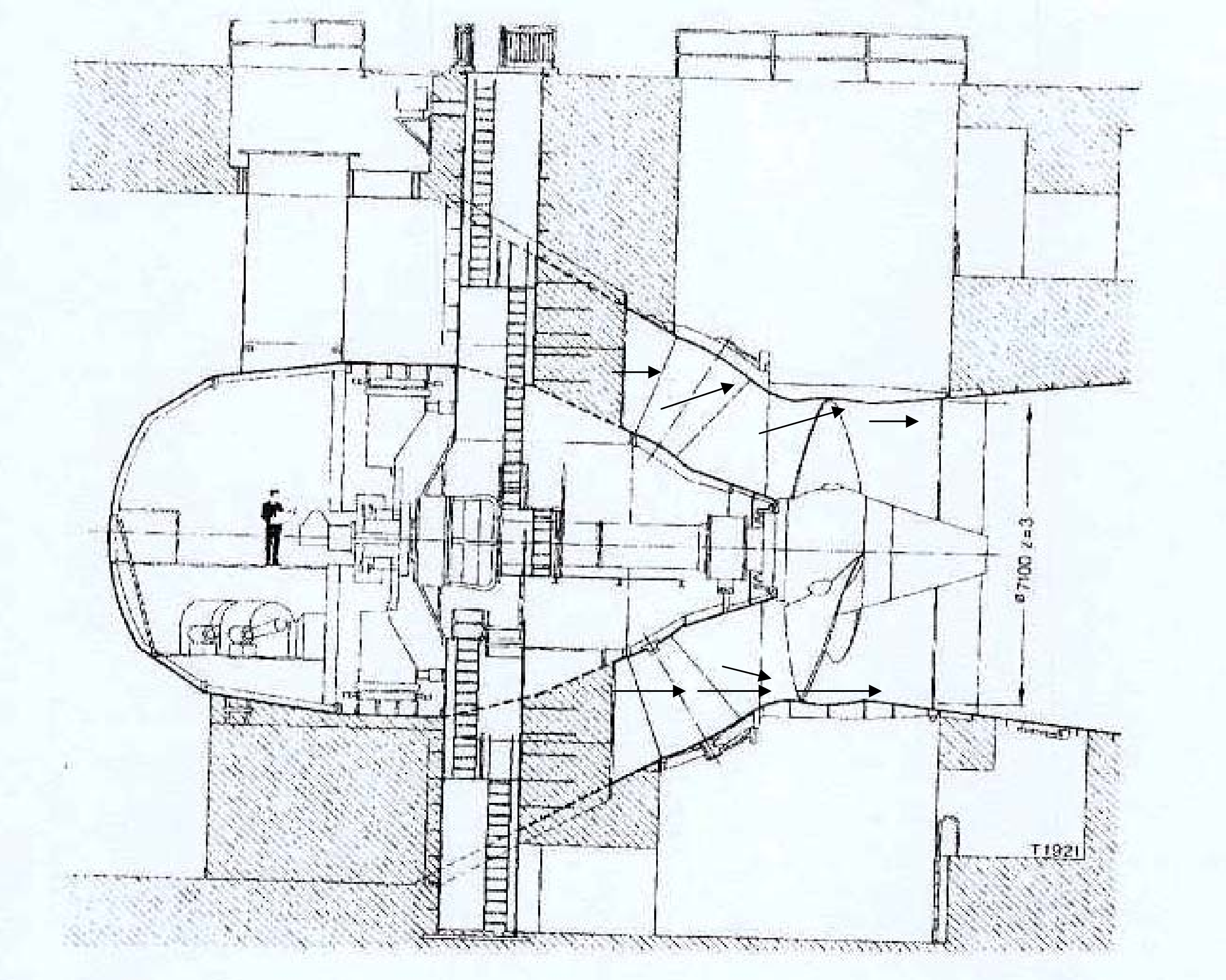
Hydraulic forces on concrete.

OPENING NOT TO BE REDUCED (MAX. 3-5 mm)

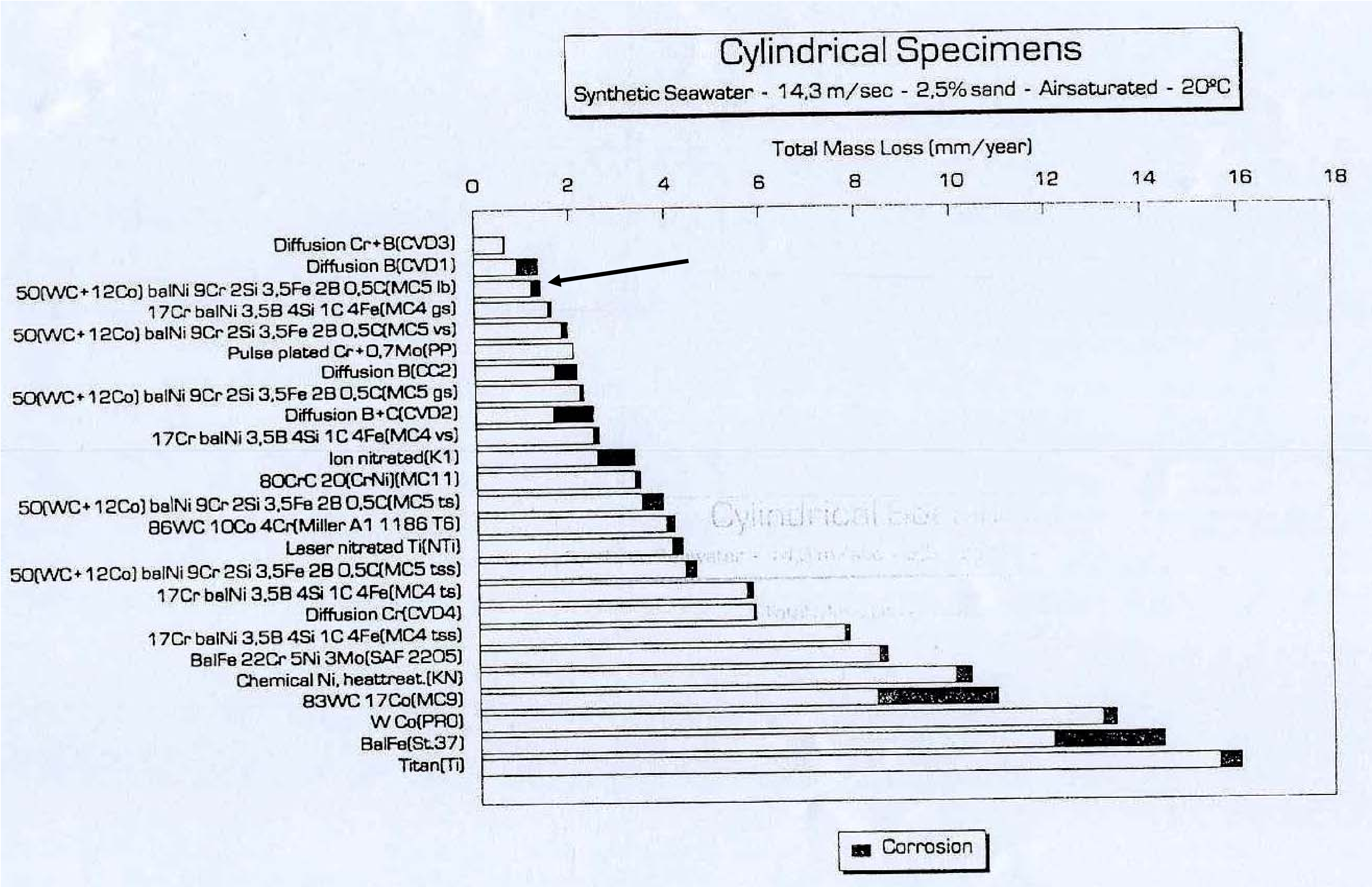
8158 TONN



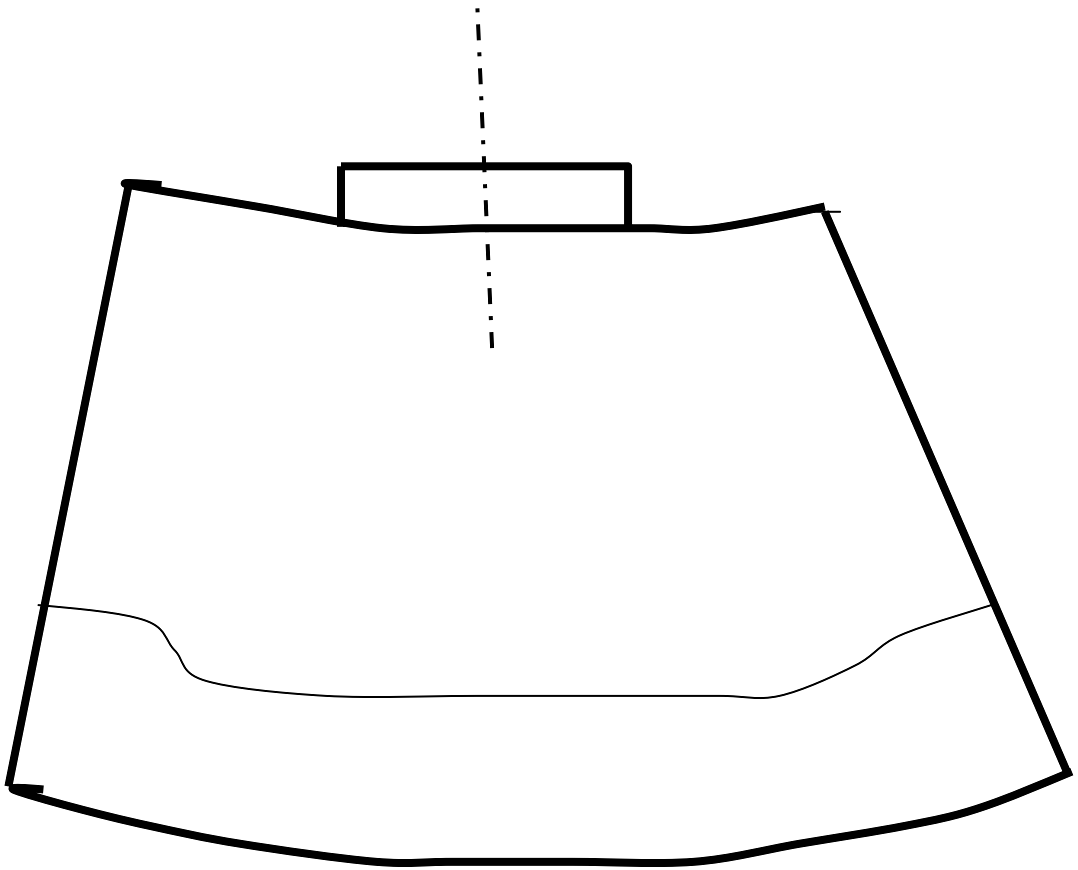
SAND EROSION



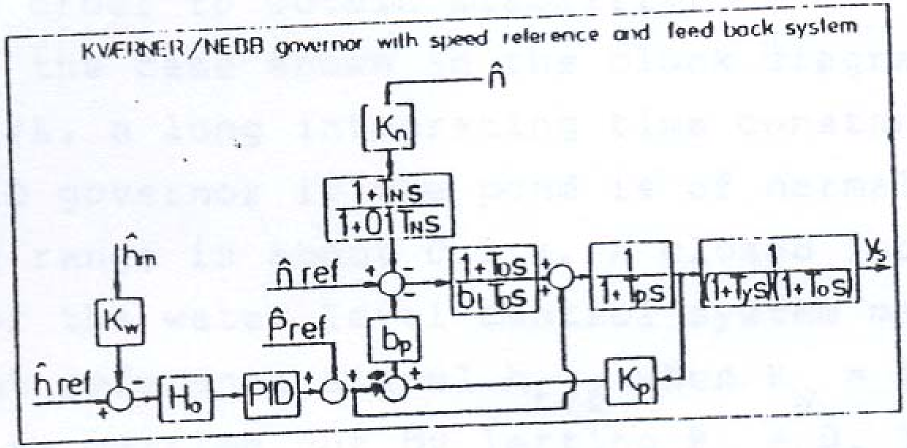
NORWEGIAN RESEARCH ON HARD SURFACE COATING



COATING OF RUNNER BLADES



FREQUENCY STABILITY ON POWER LINES ?
LEIGHT WEIGHT GENERATORS, UNSTABLE TURBINES.



From the block diagram it is substituted for different transferfunctions as shown

G = the turbine governor as shown with dotted lines

Further:

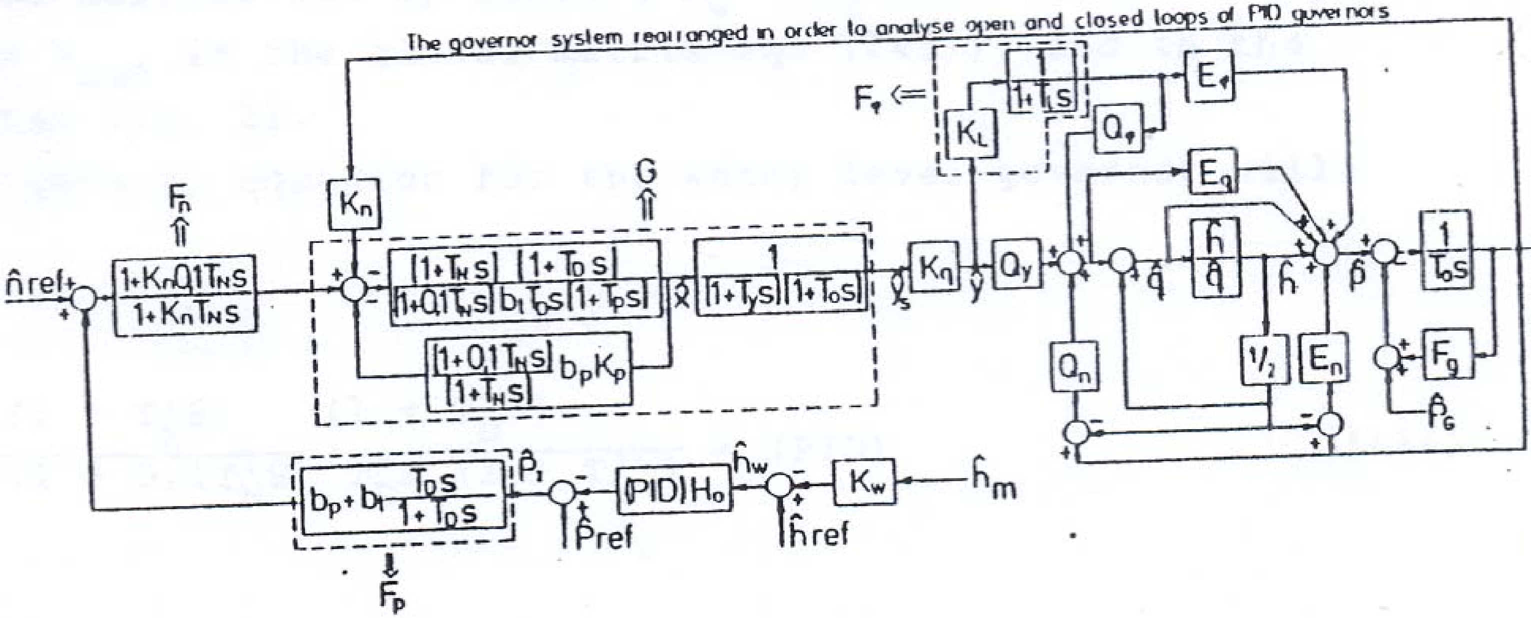
$$F_n = \frac{1+K_n\,0{,}1\,T_N\,s}{1+K_n\,T_N\,s}\ , \quad F_p = \left(b_p + b_t \cdot \frac{T_D\,s}{1+T_D\,s}\right)$$

$$F_\varphi = K_L \cdot \frac{1}{1+T_L\,s}$$

The PID governor for external governors as a water level controller may prinsipally be deseribed as

$$PID = \frac{1}{b_t'}\,\frac{(1+T_N'\,s)}{(1+0{,}1\,T_N'\,s)}\,\frac{(1+T_D'\,s)}{T_D's\,(1+T_y'\cdot s)}$$

(Note b_t' may be negative for w.l. control downstream of turbine.)



THE MOST IMPORTANT STANDARDS YIELDS:

- **FOR ELECROMECHANICAL EQUIPMENT: IEC NORMS , BULB TURBINES = TUBULAR TURBINES IEC 61366-5**

- **FOR STEEL CASTINGS: CCH 70-3**

- **BRAZILIAN INDUSTRY MEETS THESE STANDARDS IN MOST CASES.**