INAC 2013 / III ENIN
EDF Presentation

Focus on French Operating Feedback with Inland NPPs

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AGENDA

- EDF/DIN/CNEPE presentation
- French operating feedback
- Site selection criteria
- Main specificities of inland sites
- Conclusion

CNEPE presentation  1/2

- Within DIN, CNEPE (Centre National d'Equipement de Production d'Electricité) acts as architect engineer in charge of the engineering, procurement and construction with the following scope :
  - Turbine hall (CI) and related equipment
  - Heat Sink, balance of plant (BOP) and site facilities (Power transmission, demineralised plant, water treatment, security buildings)

- For both :
  - The **operating French NPPs** (900MW-1300MW-1400MW): provision of engineering support services, retrofits, NPPs life extension, upgrades of systems / components and facilities for the 58 nuclear units in operation in France
  - The **New Nuclear Projects**: EPR nuclear power stations in Flamanville 3 and in UK, china back-office, feasibility studies for new NPPs (heat sink optimisation, grid connection…) in France and overseas, new reactors studies (ACE100 / NM4).

CNEPE presentation 2/2

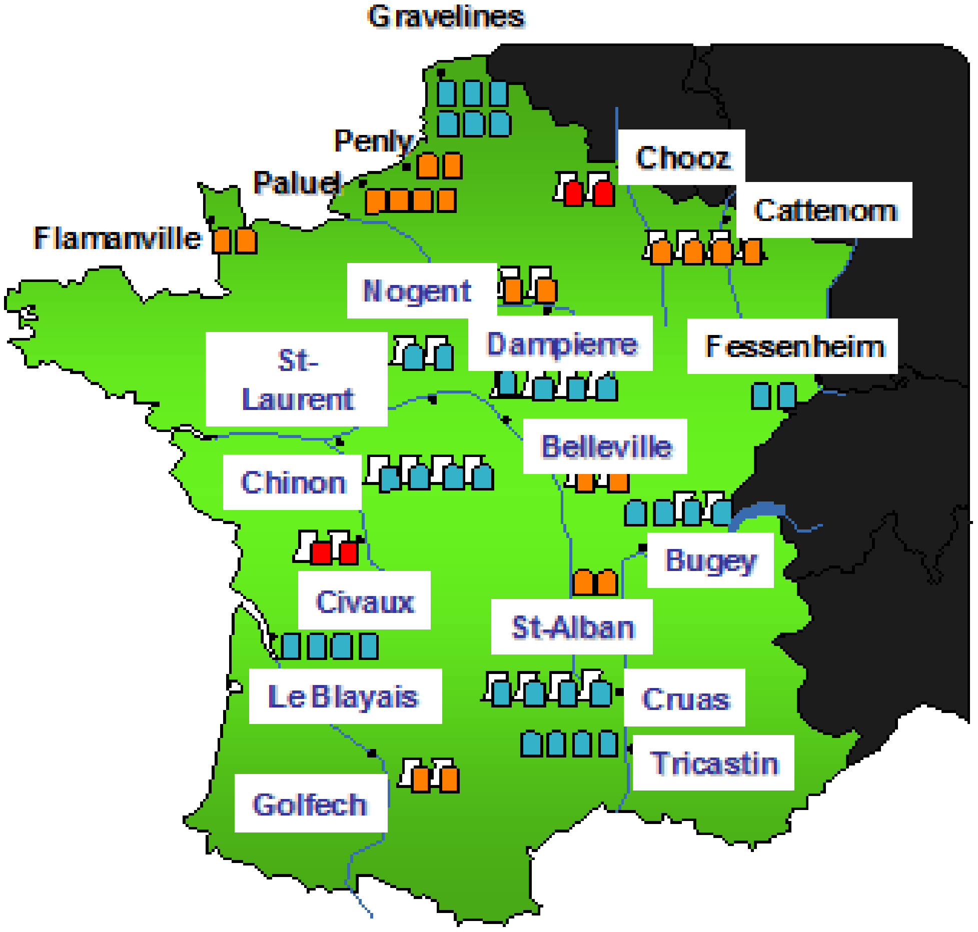
- The CNEPE core skills cover both engineering and project management

- Engineering skills related to :
  - Nuclear Safety
  - Civil works
  - Electrical systems
  - Mechanical systems
  - Instrumentation & control systems, performance tests
  - Environmental issues.

- CNEPE has the din expertise for the following equipment: generators, transformers, condensers, cooling towers, large steam turbines, pumping stations.

French NPP sites

- 19 sites, 58 units, 62 GW
  - 4 sea side
  - 1 estuary
  - 14 inland
- Wide Feedback
  - More than 1670 reactor.year
  - More than 540 site.year



Site selection criteria

4 SETS OF GENERAL CRITERIA

- **Technical / economical criteria**

  to ensure technical ability at a reasonable cost
- **Safety criteria**

  to cope with all the regulatory requirements
- **Environmental criteria**

  to ensure the mastery of impacts
- **Social / economical criteria**

  to minimize the disturbance of the local activities

+ Taking into account some specificities of inland sites

Main specificities of Inland sites

Limitation of effects on environment

- Thermal discharge
- Management of radioactive effluents
- Chemical and biological discharges

Differences in hazards to be considered

- Flooding risk evaluation
- Risk of heat sink drought
- Different types of debris and response to clogging
- Wider range of air and water temperatures

No particularity for the studies of the accident consequences for this type of site, compared to seaside sites

Limitation of thermal discharge

- **Limits on River water temperature & river heating**
  - No more than 1.5 K heating and 28 °C in the river
  - Water consumption to be compensated during lowest water level on some sites
- **Once-through circuit acceptable only for high flow rivers**
  - Rhin : Fessenheim (2 units)
  - Rhone : Bugey (2), St Alban (2) Tricastin (4)
  - Typical flow rate 40 to 50 m3/s
- **Cooling towers generally necessary**
  - Wide EDF experience with various types : natural or induced draft, cross or counter flow
  - Up to 178,5 m high (Golfech)
  - Typical discharge flow rate : 2 m3/s
  - Typical water consumption : 0.7 m3/s
- Production **limitations (2003 & 2006)**
  - Additional cooling of cooling tower discharge may help to avoid limitations

Operating feedback of main cooling towers

- **Thermal discharge**
  - In practice very limited (Loire temperature rise of 0.1 to 0.2 K at Dampierre)
  - However production limitations in 2003 and 2006 (very warm summer)
  - Additional cooling of cooling tower discharge may help to avoid limitations
- **Other environmental effects**
  - Slight reduction of sunshine around the site due to the steam plume
  - Noise due to water fall in basin (around 40 dB in site limit).
  - Replacement of condenser copper tubes by stainless steel led to development of micro-organisms (ameba, legionella) which require treatment (chemical, ultraviolet,…)
- **Operating difficulties**
  - Chemical treatment may also be necessary to limit the formation of tartar on the heat transfer media
  - Improvements were also needed following 1985-1986 winters to prevent ice formation on the heat transfer media

Management of liquid radioactive waste

- **No specificity in annual limits**
  - Limits based on best available techniques
  - Reactor type dependant (same techniques on whole series)
  - Due to improvements, releases other than H3 and C14 significantly reduced over the years
- **Need for management on river sites**
  - Releases are forbidden during flooding, to avoid inappropriate transfers of radionuclides to agricultural production
  - Limit Tritium concentration in drinking water lower than 100 Bq/l
  - Need coordination between sites on same river during low flow rates periods
  - For small rivers, long periods of flooding or low river flow rate are taken into account to assess the needed volume of effluent tanks
- **Typical limits of annual releases for one 1300 MW reactor**

Parameter	Limit
Tritium	40 TBq
Carbon 14	95 GBq
Iodine	0,05 GBq
Fission & Activation products	12,5 GBq

Management of chemical discharges

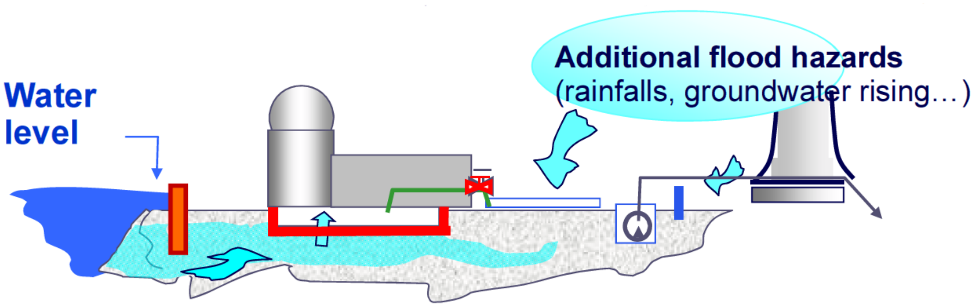
- **Sources of chemical substances**
  - From primary & secondary circuits (same as for seashore NPPs)
  - Specific from river side
    - Metals from condenser wear (Cu, Zn)
  - Specific from closed loop circuits
    - Biocid treatment (monochloramine, chlorine)
    - Antiscale treatment of cooling tower

- **Management to avoid impacts on ecosystems**
  - Use of PNEC (Predicted No Effect Concentration) from recognized international (e.g. ECOTOX of US-EPA) or national (INERIS) data bases
  - Comparison to Predicted Environmental Concentration
  - Evaluation of Chronic impact based on annual average concentrations, and Acute impact based on daily averaged concentrations
  - Impact of NPP chemical liquid discharges on public health is usually not a key factor for inland NPPs

Flooding risks

- **Initial Regulatory approach : RFS 1.2.e : two main phenomena**
  - 115 % of millenial flow rate + uncertainties (70% confidence interval)
  - Or upstream dam failure + centenial flow rate

  These evaluations need relatively complex hydraulic models for river sites
- **Blayais Flooding Feedback (1999) : Full Review + additional phenomena** + credible combinations
  - Wind induced waves (even on river)
  - Swelling due to operation of valves or pumps
  - Rainfalls : intense and short, or long duration
  - Water retaining structures (other than dams) or equipment deterioration
  - Groundwater rise

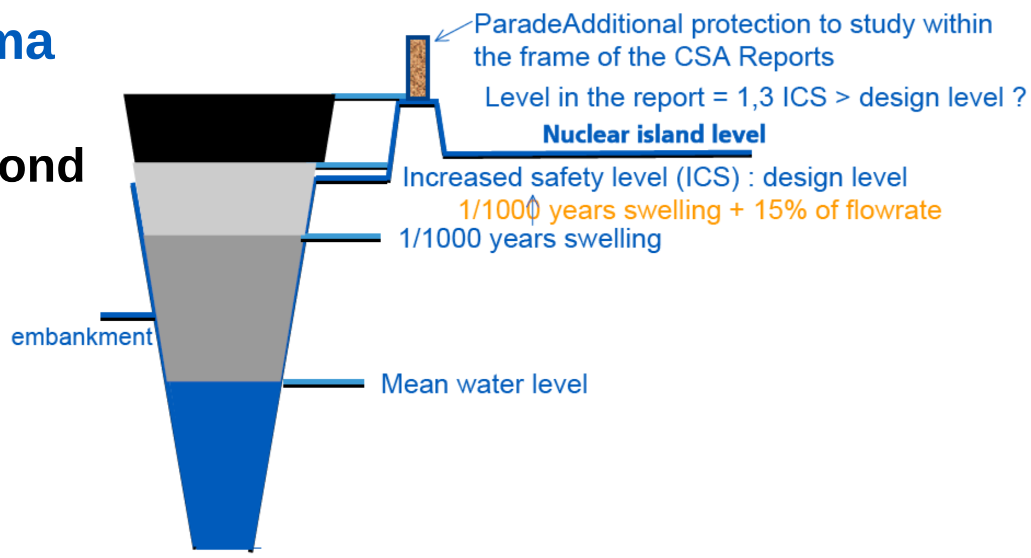


  - + Uncertainties from friction coefficient in hydraulic models
  - Periodic evaluations of changes in environment of the river (new bridges, forests,…)

Flooding risks

Additional Flooding evaluation

- **In the frame of post-Fukushima "stress-tests"**
  - **Consideration of flooding beyond the design**
    - 130 % of ICS
    - Rainfall x 2
    - Additional failures on platform
    - Consideration of potential for several dam failures in parallel valleys



- **Taken into account as safety improvement**
  - Either in the design of Hardened Safety Core
  - Or increase in whole site protection

(except for the sites which remain dry with this hypothesis)

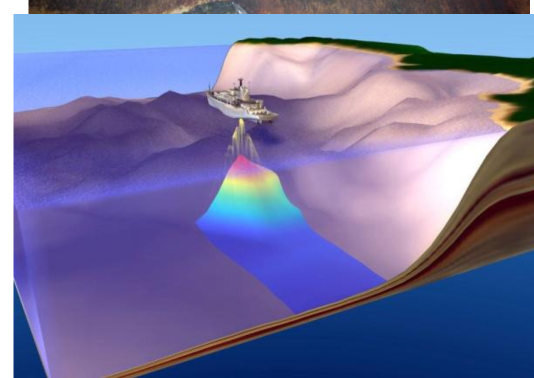
Risk of drought of heat sink

- **Several causes may lead to drought**
  - Very low flow rate in the river
  - Sediment transport (sand in Loire river)
  - Dam break or failure downstream

- **Means to ensure safety for this risk**
  - Minimum level for safety pumps generally ensured through sill in the river
  - Consideration of total loss of heat sink as design extension condition
  - Additional means on a case by case basis :
    - Management of the river flow rate with reservoirs
    - Use of a lake in diversification of river (Cattenom)
    - Use of Safety cooling tower to ensure essential service water cooling (Civaux)
    - Regular dredging
    - Additional intake structure (Chinon)

Risk of clogging of heat sink

- **Various types of clogging debris**
  - Problem similar to sea side, even if debris are different
  - Potentially reduced margins in closed loop (filtration area). The only TLHS in France occured in Cruas in 2009
- **Means to ensure safety for this risk**
  - Water capacity in case of Total Loss of Heat Sink for the whole site greater than on seaside (60h vs 24h, and more after post-Fukushima improvements)
  - Some additional means efficient against drought also protect against clogging
    - Use of a lake in diversification of river (Cattenom)
    - Use of safety cooling tower to ensure essential service water cooling (Civaux)
  - Other means that are used :
    - Use of water from main cooling towers (Bugey)
    - Very low filtration speed (Tricastin)



Risk of clogging of heat sink


Cruas 2009 - clogging

Wider range of temperatures

- **Inland sites are subject to more continental climate**

- **River with small flow rate in summer have a small thermal inertia**
  - Examples of this effect on French sites

Examples	°C	Minimum air Temperature	Maximum air temperature	Maximum water temperature
Sea side	Gravelines	-23	36,5	24
	Flamanville	-19	35	22
Inland	Cruas	-24	44,2	30,5
	Fessenheim	-32	44,1	29
	Belleville	-31	43,7	35,5

- **Main consequences on HVAC systems**

- **Freezing of water intake is more frequent for inland sites (St-Laurent 1985)** ⓘ
  - But frazil may also occur on French sea sites

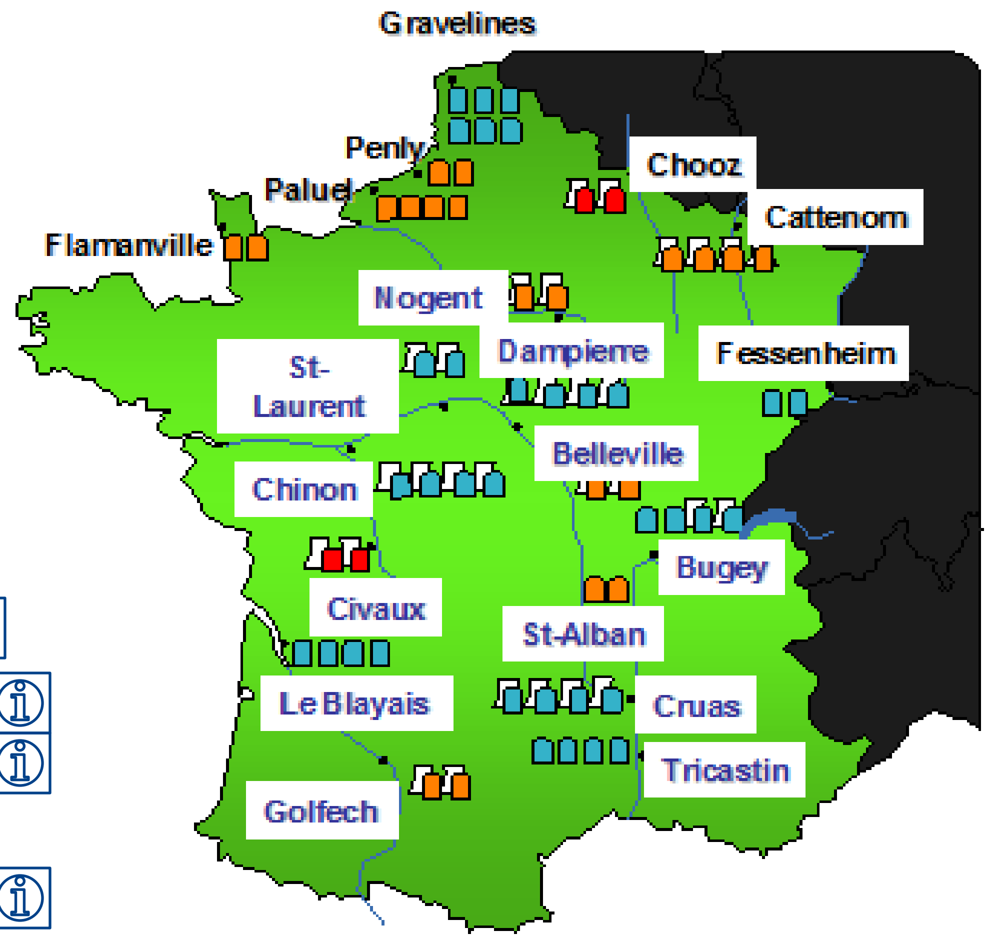
Conclusion

- The main specificity of inland sites is the design of heat sink
  - Wet cooling towers are generally required to reduce thermal discharges
  - Additional devices may be necessary in case of low flow rate : discharge cooling, safety cooling tower
  - Environmental effects of these towers are reduced, and manageable
- Management of liquid wastes (radiological or not) needs more anticipation
  - But this does not constitute a challenge
- Studies of hazards show some difficulties, different from those for seaside sites
  - But none of them introduce serious challenges, especially for a new site
- EDF has an operating feedback of more than 1260 reactor.year with inland sites
  - This feedback led to several improvements, and enables to confirm that their safety is comparable to seaside sites

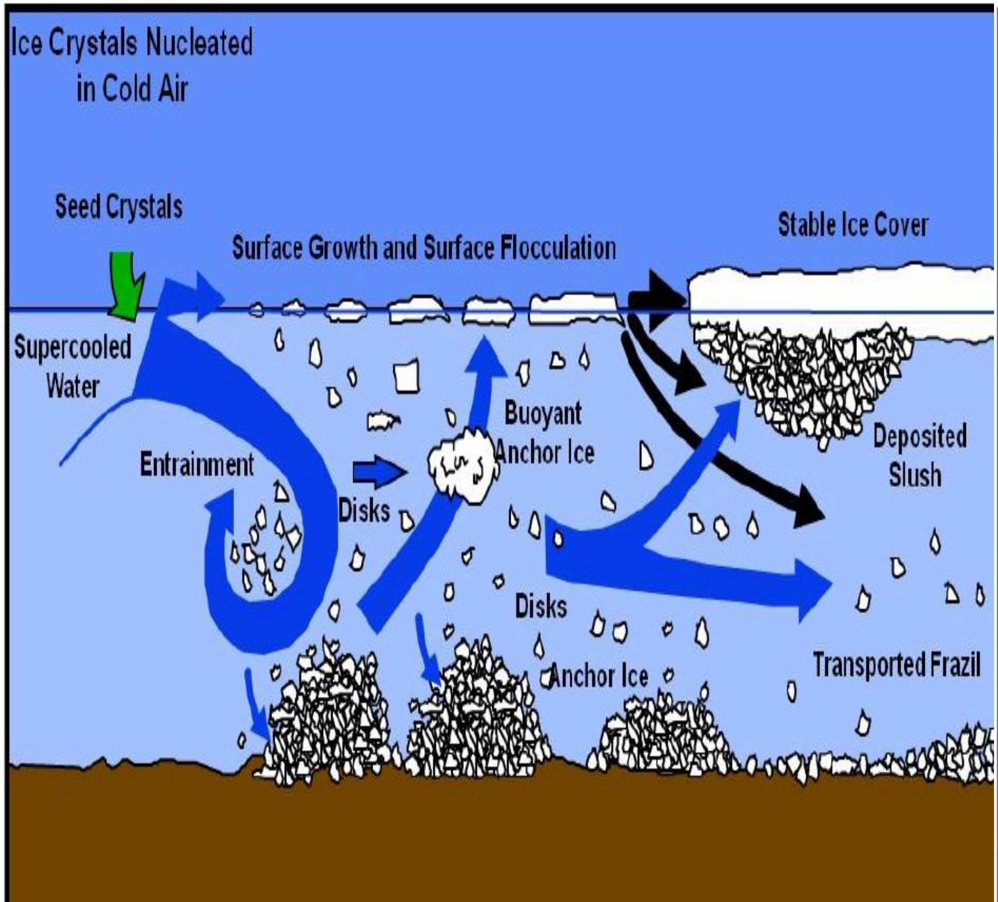
Thank you for your attention

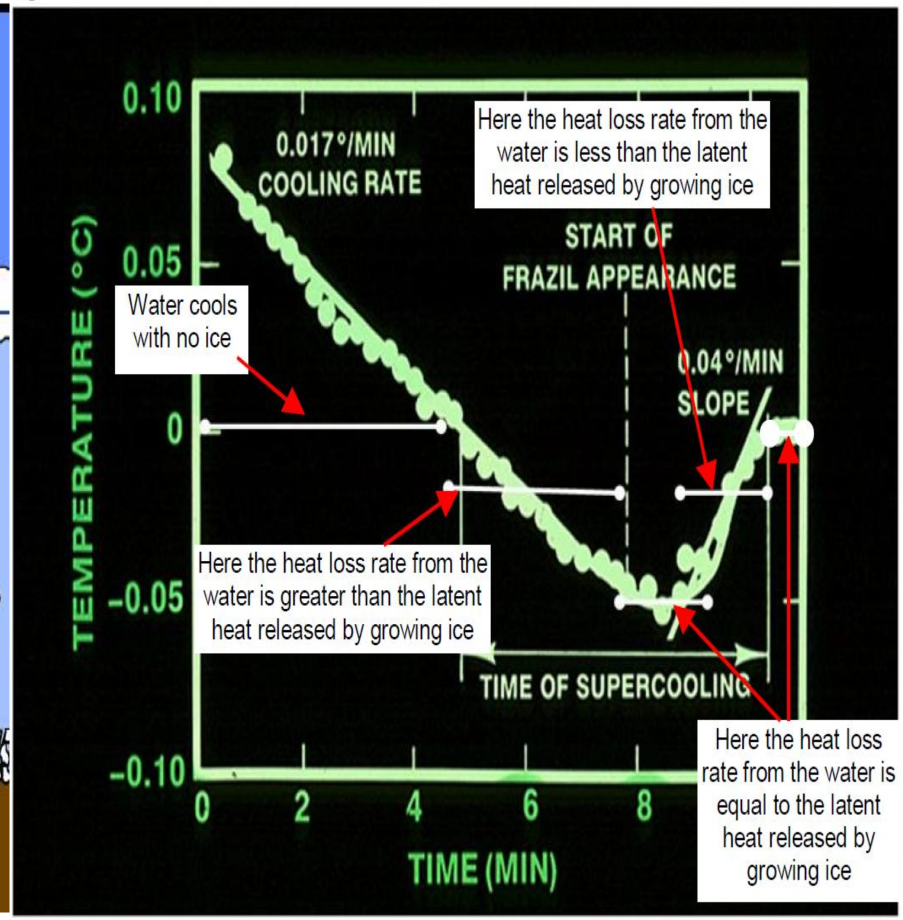
Back Up – Site pictures

- 4 sea side
  - Gravelines
  - Paluel
  - Flamanville with EPR
  - Penly
- 1 estuary
  - Blayais
- 14 inland
  - CP0 : Fessenheim and Bugey
  - CP1 / CP2 : Dampierre, Tricastin Saint-Laurent, Chinon and Cruas
  - P4/P'4 :Saint-Alban, Cattenom Belleville, Nogent and Golfech
  - N4 : Chooz and Civaux



Definition of Frazil Ice





<u>'Active'</u> (and adhesive) **<u>frazil ice</u>** may be defined as "***nascent ice crystals that form within water with turbulent flow in the absence of an ice cover, when the water temperature is below the freezing point***".
When water temperature rises once again to its freezing point, **the frazil ice enters into its <u>'passive'</u>** (non-adhesive) phase, **agglomerates, float and drifts on the surface**.

Definition of Frazil Ice