Ice Class Rules

Description and Comparison

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Outline

- Main ice class rules and areas of application
- Short History
- Rule Comparisons
  - Design scenarios
  - Ice mechanics concepts
  - Strength formulations
  - Performance issues
- Equivalency Issues

Brazilian Research Vessel *Mar Sem Fim*, sunk by ice pressure, April 2012, Antarctica,
Source: sometimes-interesting.com

Ice Class Areas

Ice Class Rules have evolved from:

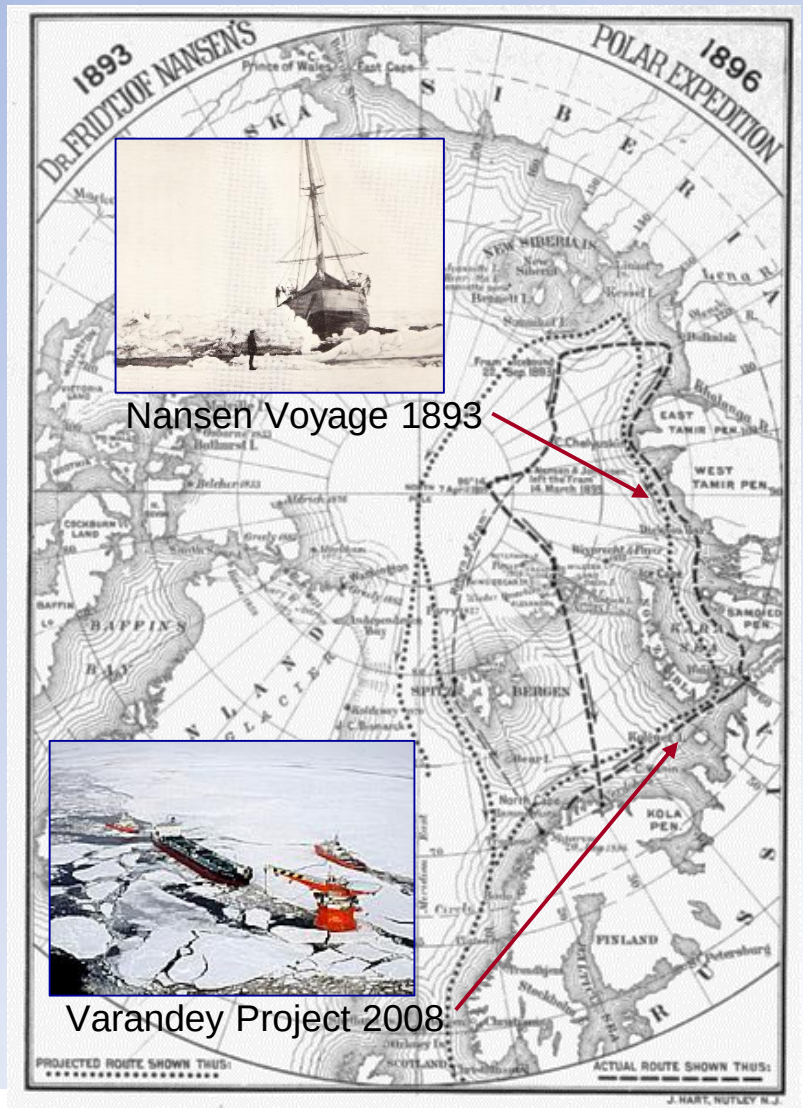
Government Policy

and

Classification Society Response to Clients

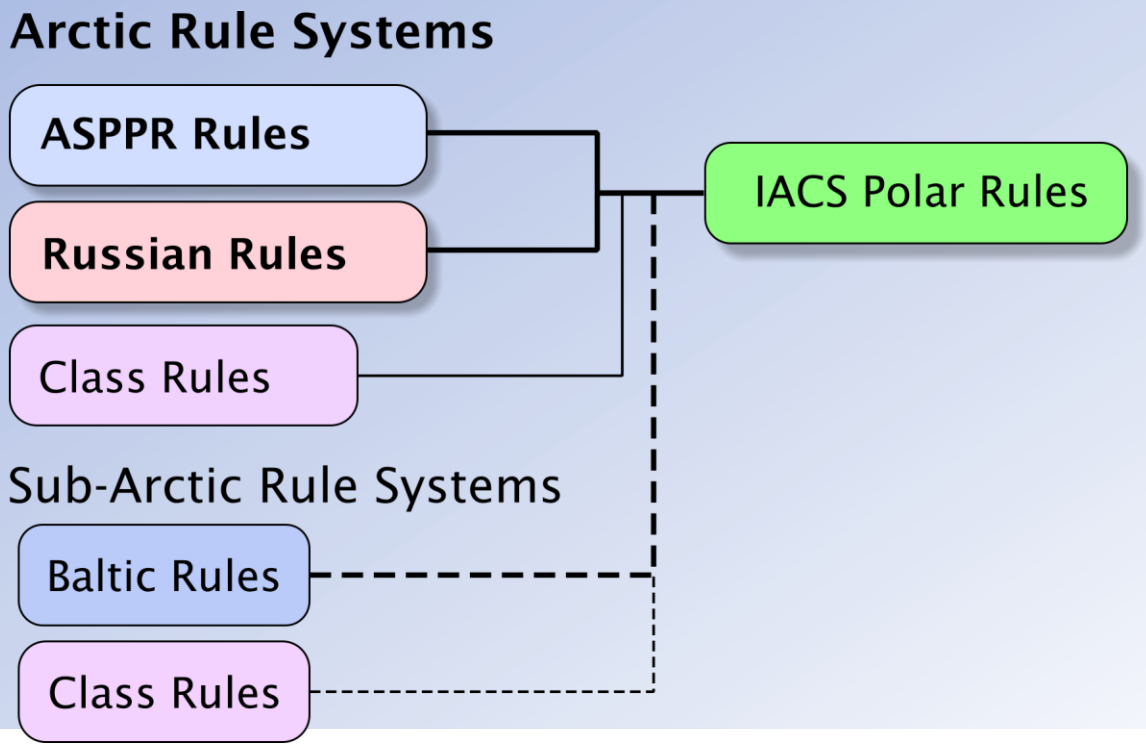
Short History of Ice Classes

- 1890s-1960s
  - Finnish-Swedish (Baltic) rules evolved (1AS in 1965)
  - Early classification society rules
- 1970s-1980s
  - Baltic Rules revised in 1971,
  - First ASPPR Rules 1972, revised 89 (‘95)
- 1990s-2000s
  - IACS Polar Rules developed (1992-2000)
  - RR revised (1995, 2008)
- 2012 - IACS UR fully adopted in ABS
- 2014 – IMO Polar Code (discussions underway)



IACS Polar Class Rules (URI)

The Polar Rules were developed by experts who represented the knowledge base behind the main ice class systems in the world, including Canada, Russia, Finland and Class Societies.



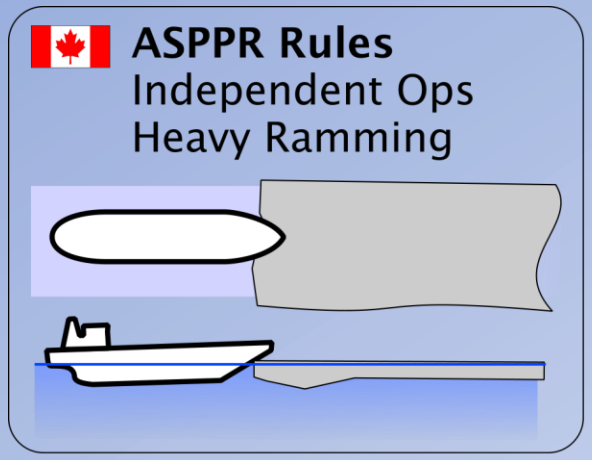
Comparing Ice Class Rules

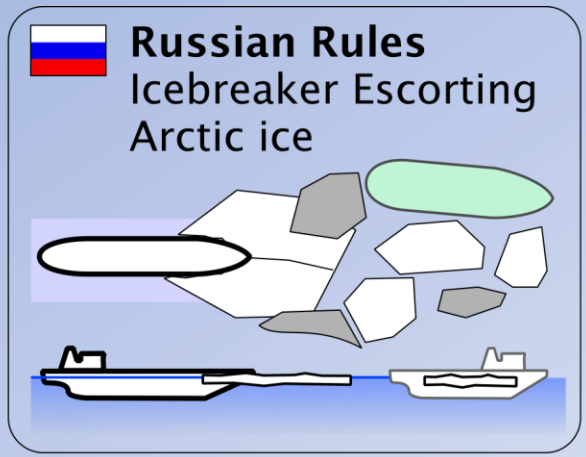
All rule system are unique. Each system uses its own unique approach to ice loads and strength, and arrives at a set of class requirements in its own way:

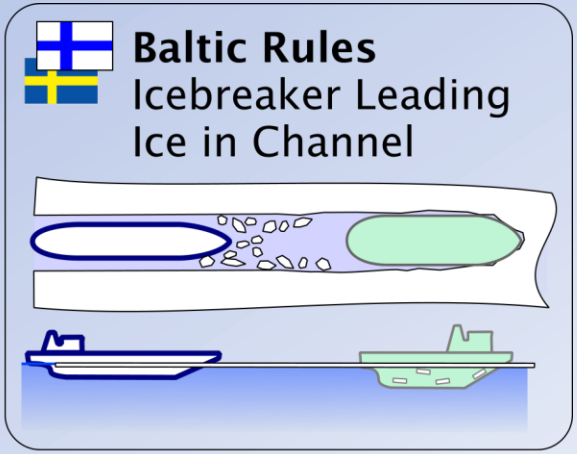
- Design scenarios
- Ice mechanics concepts
- Strength formulations
- Operational
- Parameters considered

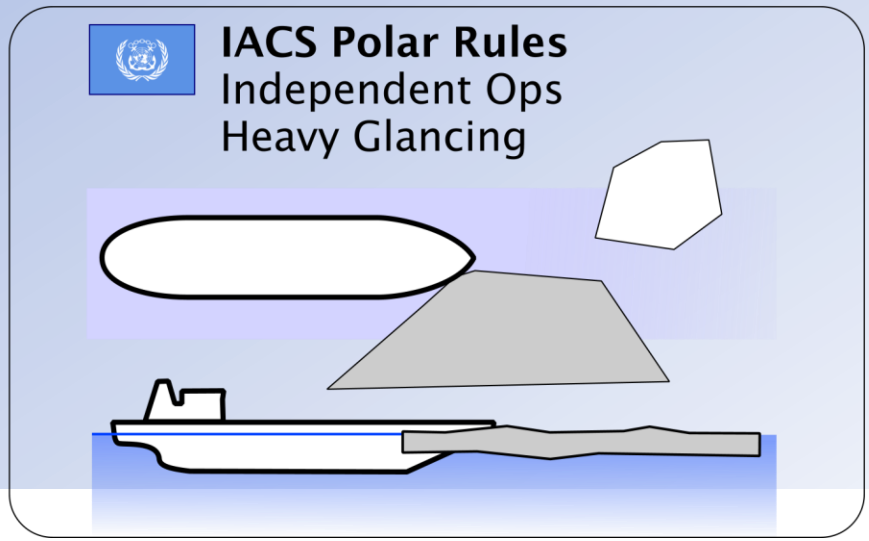
Ice Class Design Scenarios

Most scenarios are ‘nominal’, IACS scenario is explicit









Ice Load Models

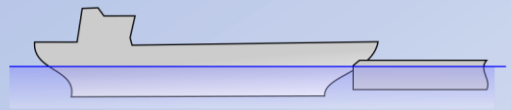
Force or pressure based

ASPPR Rules

Design load:
Ramming Model - Fmax
+ Pressure-Area Effect

Russian Rules

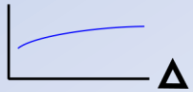
Design load:
Popov Glancing load
+ Khesin-Kurdumov
(extrusion model)

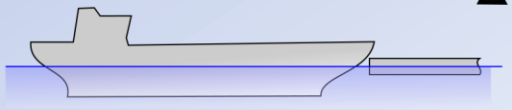


Baltic Rules

Design load:
emperical pressure

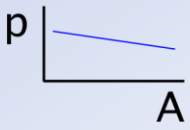
$k = \sqrt{\Delta P}$

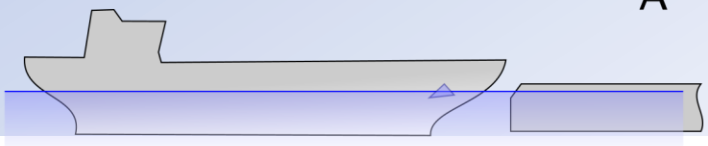




IACS Polar Rules

Design load:
Popov Glancing load
+ Pressure-Area Effect





Ice Strengthened Hull Areas

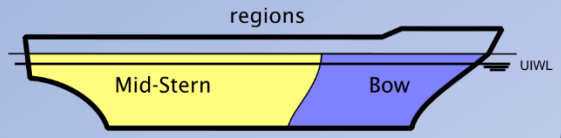
Bow + others

ASPPR Rules

4 hull areas

bow, mid/stern, bottom

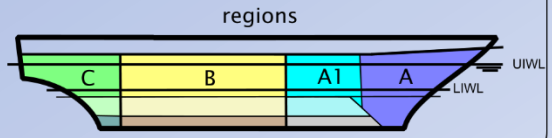
+ ice skeg



Russian Rules

13 hull areas

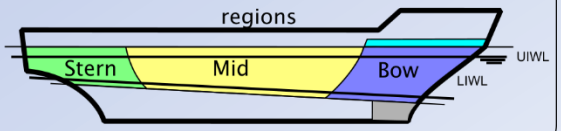
3x4 +bow



Baltic Rules

3+2 hull areas

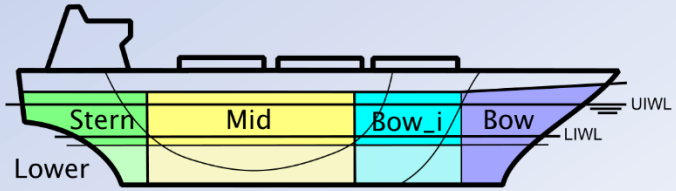
~~lower and bottom~~



IACS Polar Rules

10 hull areas

3x3 +bow

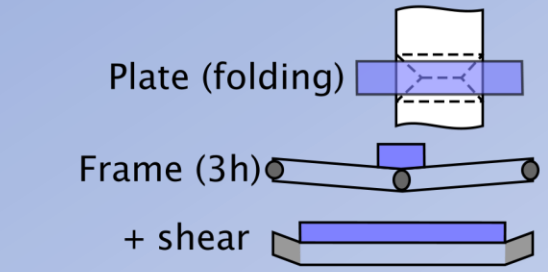


Structural Strength Approaches

Plastic vs Elastic

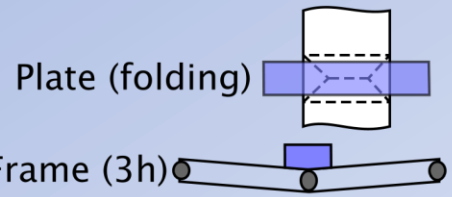
ASPPR Rules

Plastic Capacity Models



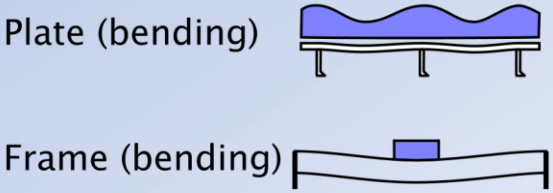
Russian Rules

Plastic Capacity Models



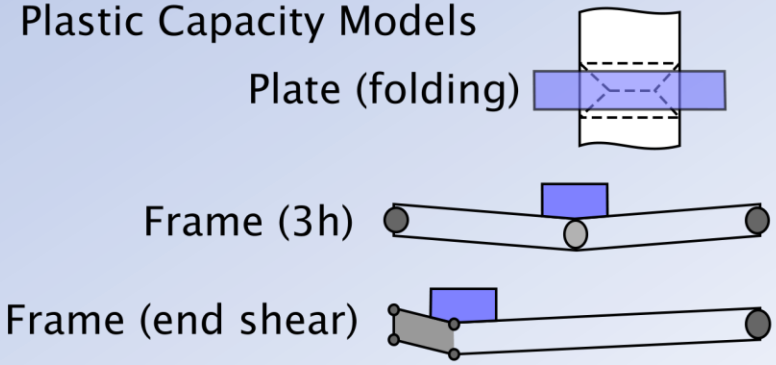
Baltic Rules

Elastic Strength Models



IACS Polar Rules

Plastic Capacity Models



Traffic Management and Ice Performance

Safety Only vs Safety & Performance

Question: Do power and IB support help safety?

ASPPR Rules

No performance requirements
No Icebreaker support
- independent navigation

No Icebreaker support
- independent navigation

Canada uses Zone/Dates
+ Ice Regime System

Russian Rules

Ice performance assessed
- Icebreaker support may be required for access

Russia uses Sea Areas and Winter Severity Table

E.G.	Laptev
	Ex H M E
Arc8 IN	- * + +

Baltic Rules

Power Required
- Icebreaker support provided (more strength = lower fees)

TRAFI Manages with IB Fleet

IACS Polar Rules

No performance requirements
Just a construction standard
- actual navigation control left to others
- performance guidance (e.g. safe speed) under development

Polar Classes

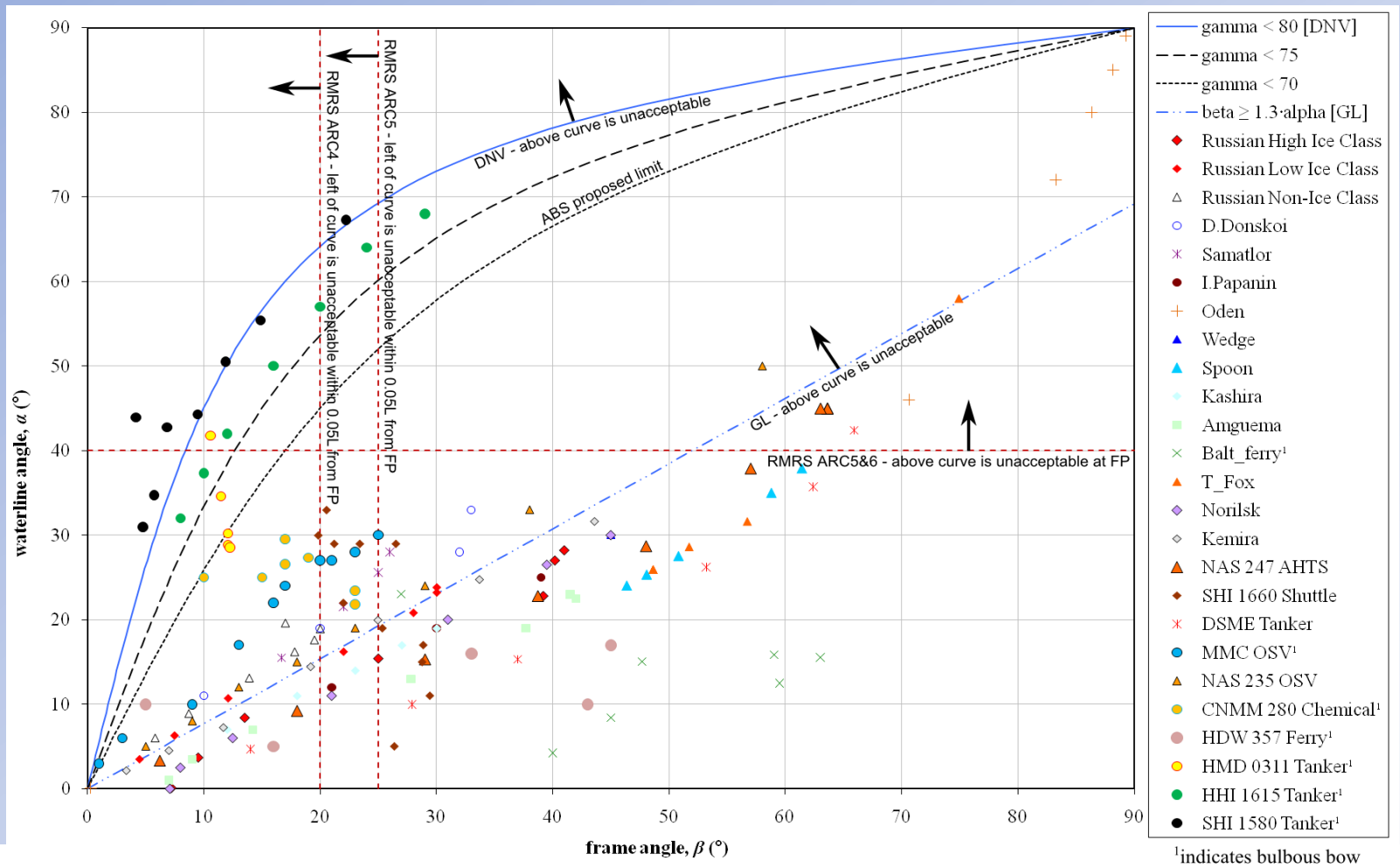
- **Lowest Polar Class (PC7):** should have general levels of strengthening roughly comparable to RRS Arc 5 and Trafi 1A
- **Highest Polar Class (PC1):** capable of independent operation without limitations, above Arc9 required for Russian Waters.
- The Polar Rules provide a minimum level of ice strengthening. All Polar Classes can encounter ice conditions that could damage the structure
- Ice Class is evolving. Experience needed!

		RRS	IACS	
		Arc9[i] Arc8[e] Arc7 Arc6	PC1 PC2 PC3 PC4 PC5	Year-Round Navigation in Arctic Waters
Winter Navigation in Sub-Arctic Waters	1AS 1A	Arc5 Arc4	PC6 PC7	Summer Navigation in Arctic Waters
	1B 1C	Ice3 Ice2 Ice1		
	TRAFI	RRS		

Notes:
i - independent operation allowed in all Russian sea areas in all winters
e - icebreaker escorted operation allowed in all Russian sea areas in all winters

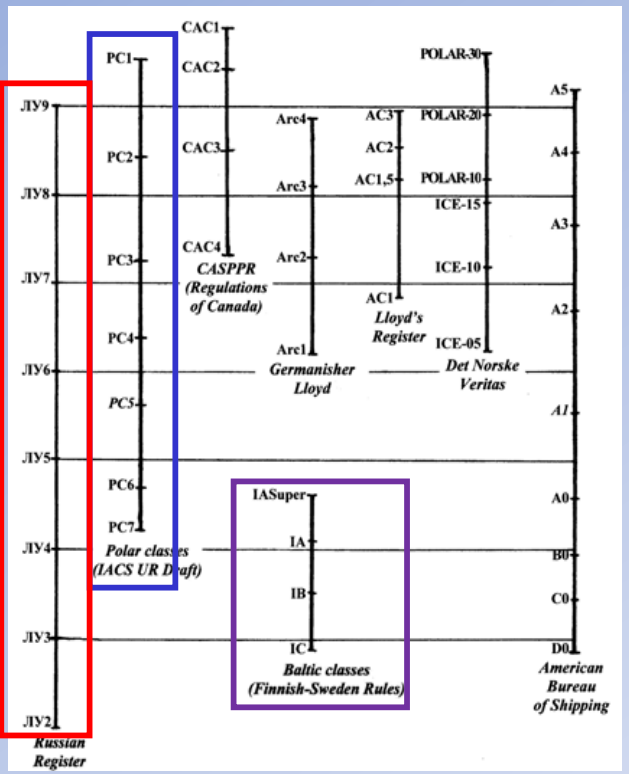
Icebreaking Hull Forms

Correspondence depends on hull form (formulations differ).



Ice Class Correspondence Tables

Correspondence depends on what is assessed.



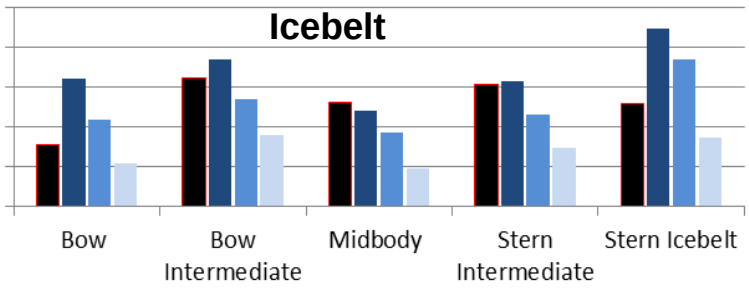
Source: Appolonov et al. 2007

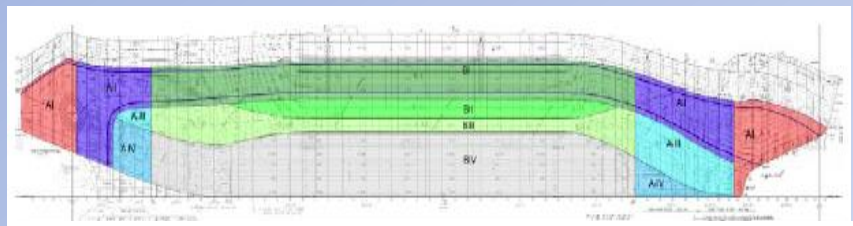
	Ice Class				
RS (Rules 2008)	Arc8	Arc7	Arc6	Arc5	Arc4
RS (Rules 1995)	-	ULA	-	UL	L1
IACS POLAR	**PC2**	**PC3**	**PC4**	**PC5, 6**	**PC7**
CASPPR, 1995	CAC2	CAC3	CAC4	A	B
ABS	**A4**	**A3**	**A2**	**A1**	**A0**
DNV	POLAR-20	POLAR-15	POLAR-10 ICE-15	ICE-10 ICE-1A*	ICE-05 ICE-1A
LR	AC2	AC1.5	AC1	1AS	1A
GL (Old Rules)	Arc3	Arc 2	Arc1	E4	E3
FSICR	**-**	**-**	**-**	**1A Super**	**1A**
BV	-	-	-	1A Super	1A
NKK	-	-	-	1A Super	1A
KR	-	-	-	ISS	IS1
CCS	-	-	-	B1*	B1
RINA	-	-	-	1AS	1A

Source: CNIIMF (Russian Federation)

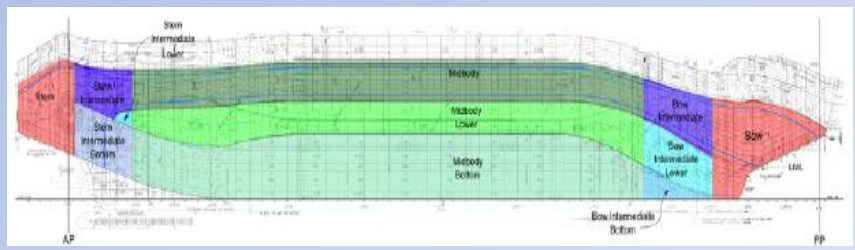
RMRS Arc6 Double Acting Arctic Tanker

Framing



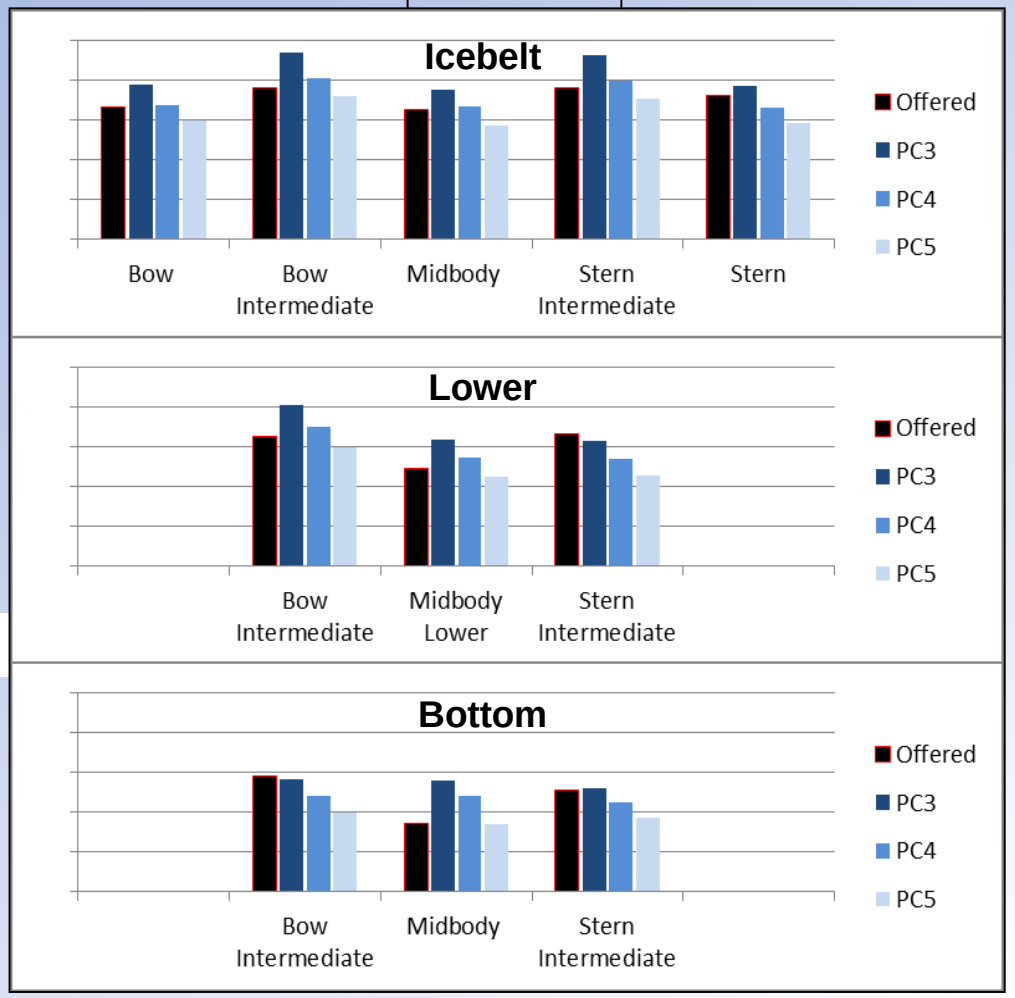


RMRS Ice Class Arc6 – Ice Hull Areas



IACS Polar Class PC4 – Ice Hull Areas

Plating



Thank You For Listening

Grounded Icebergs near St. John's