CRF 2024 Rating Formulae

NOTES: 1. CRF formulae, factors and ratings are subject to change each calendar year
2. Text in red denotes changes to CRF 2023 for CRF 2024

12/28/23

												Notes
Base Rating	**R1=0.06 * (L * S) / (.75*DSPS/64)^.33 + 0.3*L + 0.20*S + DC + LBRC + StabC**											1
Rated Length:	**L=Base Sailing Length (L1) + a length increment (DelL) for recent designs with broad sterns**											
	L = L1 + DelL											
	If LWL>=0.65*LOA,	L1 = 1.02*(LOA + 4* LWL) / 5										2
	If LWL<0.65*LOA,	L1= 1.02*(LOA + 4*0.65*LOA) / 5										3
	If Age < 1990,	DelL = 0										
	If Age => 1990 & Bm10 / Bmax <= 0.75:	DelL = 0										4
	If Age => 1990 & Bm10 / Bmax > 0.75:	DelL = L1 * [15*{(Bm10 / Bmax) - 0.75} ^ 2.3]										
Rated S:	**S=Sq Root of upwind + downwind sail areas, adjusted for rig and shroud types**											5
	S = {Rig Type Factor*Shroud Type Factor*(RSAup + RSAdn) / 2} ^0.5											6
	RSAup; Rated SA, Upwind;	RSAup = Jib + Main + Mizzen + Foresail										
		RSAup=RSAF + RSAM + RSAY + RSAG										
	Rated Foretriangel Area, if LP% >1;	If LP% > 1.0:	RSAF = 0.55 * IG * J * {1 + 1.5 * ((LP% * J) - J)/(LP% * J)}									
	Rated Foretriangel Area, if LP% <=1;	If LP% <= 1.0:	RSAF=0.55*.96*(IG62+j^2)^0.5*J*LP%									
	Rated Mainsail Area, for Jib Headed Main;	w/o main girths:	RSAM=1.027*0.45*P*E									
		w/main girths:	RSAM=MSA_inc*0.75*(P/2*(MGM+E)/2+P/4*(MGM+MGU)/2+P/8*(MGU+MGT)/2+P/8*(MGT/2)									7
			MSA_inc=0.28*MGT/E+0.965									
			Note! Declarations for MGM, MGU & MGT (mainsail girths) required for all new mains									
	Rated Mainsail Area for Gaff Headed Main;	If PG> 0:	RSAM=0.55*PG*E									
	Rated Mizzen Area;	If PY> 0:	RSAY=0.5*PY*EY									
	Rated Area Between Masts, Schooner's;	RSAG=the largest of RSA_Stay, RSA_Fore and RSA_Golly										8
	Staysail hoisted from single halyard:	If P1=0 **AND** P3>0:	RSA_Stay=P3*B1*0.5									
	Foresail only with its clew trimmed to a boom:	If P1>0 **AND** P3=0:	RSA_Fore=P1*B1*0.6									
	Staysail hoisted from two halyards (eg Gollywobbler):	If P1>0 **AND** P3>0:	RSA_Golly=(P1+P3)/2*B1*0.6									
	RSAdn; Rated SA, downwind;	RSAdn = Spin + Main + Mizzen + Foresail										
		RSAdn=SPIN + RSAM + RSAY + RSAG										
		If S-SPIN > A-SPIN:	SPIN=S-SPIN									
		If S-SPIN =< A-SPIN:	SPIN=A-SPIN									
		w/o declared SMW:	S-SPIN=0.95*(ISP^2+J^2)^0.5*1.8*SPL*0.8*1.05									9
		w/declared SMW:	S-SPIN=The greater of S-SPIN21 and S-SPIN22									
			S-SPIN21=0.95*(ISP^2+J^2)^0.5*1.8*SPL*0.8*1.05									
			If SMW>1.8*SPL, S-SPIN22=	S-SPIN21*SMW/SPL/1.8								
			If SMW=<1.8*SPL, S-SPIN22=	S-SPIN21								
				SMW=declared s-sail mid width required for all new s-sails								
		w/o declared AMG:	A-SPIN=0.95*(ISP^2+TSP^2)^0.5*1.75*TSP*0.75*1.0									
		w/declared AMG:	A-SPIN=The greater of A-SPIN21 and A-SPIN22									
			If AMG>1.8*TPS, A-SPIN22=	A-SPIN21*AMG/TPS/1.8								
			If AMG=<1.8*TPS, A-SPIN22=	A-SPIN21								
				SMW=declared s-sail mid width required for all new s-sails								
Displacement	**DSPS**	**Declared value for boat weight as raced, without crew, in pounds**										10

	Draft Correction	**DC**	**Based on the difference between a Base Draft (BD) and the Rated Draft (RD)**	11
			If RD>BD: **DC = 0.2 * L1 * ((RD/BD)^1.00 - 1)**	
			If RD=<BD: **DC = 0.2 * L1 * ((RD/BD)^2.0 - 1)**	
			Base Draft: BD = -0.0006 * L1^ 2+ 0.192 * L1+ 1.16	12
			Rated Draft: If no centerboard RD = DM	
			If Brd down draft (DMcb) > fixed draft: RD = DM + 0.60 * (DMcb-DM)	13
	Length/Beam Ratio Corr.	**LBRC**	**Based on the difference between a Base Length Beam Ratio and a Rated Length Beam Ratio**	14
			LBRC = 0.25 * L *{(RLBR / BLBR) ^ 0.35 - 1.0}	
			Base LBR: BLBR= -0.0002*L1^2+0.0375*L1+2.06	15
			Rated LBR: RLBR = L/Bmax	
	Stability Correction	**StabC**	**Based on the difference between a base righting moment and a calculated righting moment.**	16
			Makes use of declared ballast weight, calculated hydrostatics, and a calculated default crew weight	
			If Rmtot > Rmbase: StabC = 0.10 * L1 * ((RMtot / RMbase)^2.65 -1.0)	17
			If Rmtot =< Rmbase: StabC = 0.10 * L1 * ((RMtot / RMbase)^0.2 -1.0)	18
			RMtot = RMhull + RMCrew	19
			RMhull = DSPS * GMt * 0.0175	
			GMt = It/(DSPS/64) + VCB - VCG	
			It=BWL^3*L*0.034	
			BWL=Bmax^.92*(Dh*7.25/Bmax)^0.08	
			VCB = -1*(((DSPS/64-Ballast/690) * .35 * Dh) + (Ballast/690 * (Dh + (DM - Dh)/2)))/(DSPS/64)	
			Dh = (DSPS/64 - Ballast/690) / (LWL * Bmax * 0.9 * Cp * Cms)	
			Assumed canoe body Coefficient: Cp=0.55, Cms=.65	
			VCG = ((DSPS - Ballast) * CGnet + (Ballast * CGkeel)) / DSPS	
			CGnet = 0.60 * (L1/Dh) ^0.5	20
			CGkeel = -(Dh + (Dm-Dh)/2) * (Keel Factor+0.03) ^3	
			If Bm10/Bmax > 0.75: RMcrew = (CrewCt - 2) * 185 * ((Bm10+Bmax)/2 * 0.57 - 0.5 - 0.1*Dh)	21
			If Bm10/Bmax =< 0.75: RMcrew = (CrewCt - 2) * 185 * (Bmax * 0.45 - 0.5 - 0.1*Dh)	
			CrewCt = CrewWgt / 185	22
			CrewWgt = {(DSPS/2240 / (0.01*LWL)^3)/254)^0.375 * (RmHull/(DSPS*Bmax)/0.006)^0.4 * L1^1.5 * 7.6	23
			RMBase = 24.2*(BWL*L1^0.25)^2-388*(BWL*L1^.25)+2756	24
			If RmTot > RMBase; StabC=0.10*L1*((RmTot/RmBase)^1.60-1)	25
			If RmTot =< RMBase; StabC=0.10*L1*((RmTot/RmBase)^0.20-1)	
CRF 2023 Rating		**Rating**	**R(ft) = R1 * Prop * DLF * SaDF * Keel * Spar * MAF**	26
			R(sec/mi) = 0.6* 3600 * {1/(Rft)^0.5 - 1/(100)^0.5} - 90	27
			R(GPH) = R(sec/mi) + 535	28
	Prop Factor (Prop)	**Prop**	**Prop = assigned prop factor, based on installation type**	29
	Disp/Length Factor	**DLF**	**Based on the difference between a base Disp/Length ratio and the actual Disp/Length ratio**	
			If DLFbase > 1.015; DLF = DLFbase + (1 + DLFbase - 1.015)^4.0 -1	30
			If Base DLF=< 1.015; DLF = DLFbase + (1 + DLFbase - 1.015)^1.0 -1	
			Base DLF = {(-0.0198*L2- 4.0423*L2+376) / ((Disp/2240) / (0.01 * L) ^ 3)} ^ 0.025	31
	Sail Area/Disp Factor	**SaDF**	**Based on the difference between a base SA/Disp ratio and the actual SA/Disp ratio**	
			If SaDFbase > 1.0130; SaDF = Base SaDF + (1 + SaDFbase -1.013)^5.0 - 1	32
			If SaDFbase =< 1.0130; SaDF = Base SaDF + (1 + SaDFbase -1.013)^0.5 - 1	
			Base SaDF = ((S ^ 2 / (DSPS/64) ^ 0.67) / (0.001*L1^2+0.2208*L1+19.15) ^ 0.040	33
	Keel Type Factor	**Keel**	**Keel =Assigned Keel Factor, based on keel type**	34
	Spar Material Factor	**Spar**	**Spar=Assigned Spar Factor, based on spar construction material**	35
	Moveable Appendage Factor	**MAF**	**MAF = Moveable Appendage Factor (for a keel Trim Tab, if fitted)**	36

Notes	Comments
1	The basic architecture of the 2017 reformulation of CRF was adapted from Nat Herreshoff's **Universal Rule** and from Olin Stephens' (et al) **International Offshore Rule**. Despite shortcomings exposed by agressive exploitation of loopholes over time, early versions of IOR did a quite good job of handicapping a variety boat boat sizes and types until it fell out of favor due to the humps, bumps and hollows that came to plague it in later years.
2	Effective sailing length 'L' is a primary driver of performance, and is taken as a weighted average of LOA and LWL, with LWL recognized as having a stronger effect on performance potential than LOA.
3	A cap on total overhang of 35% of LOA (typical of International Rule boats) limits any rating advantage stemming from extreme overhang lengths and/or profile slopes (eg Sonder and Square Meter classes)
4	A declaration for Bm10 is only required for design dates after 1990. It addresses the added effective sailing length resulting from broad, powerful sterns in some contemporary designs.
5	The square root of sail area is taken to keep the rated units uniform in linear feet. For non-spinnaker ratings, RSAdn = RSAup
6	See table of assigned Rig and Shroud Type factors
7	CRF 2023 addresses mainsail roach profiles that vary from the .22*E (MGT), .38*E (MGU) and .65*E (MGM) that were previously taken as defaults. Starting with CRF 2022, calculations for RSAM depend on actual measured MGT, MGU and MGM, that are required declarations for newly built mainsails only. Mainsails whose roach is larger than the previous default will now rate slightly faster, and roaches that are smaller will rate slightly slower.
8	RSAG now includes includes the area of 'Gollywobbler' type sails set flying from ahlyards led to both masts, and has an error in previous coding corrected.

9	CRF 2023 addresses spinnaker mid widths that are greater than 1.8*SPL (s-sails) or 1.8*TPS (a-sails). Starting with CRF 2022, calculations for S-SPIN depend on actual measured SMW and/or AMG, that are required declarations for newly built spinnakers. Spinnakers whose mid widths are larger than 1.8*SPL (s-sails) or 1.8*TPS (a-sails) will rate slightly faster. Spinnakers whose mid widths are smaller than the default will not rate slower, to discourage attempts at rating optimization via small spinnaker area.
10	The declared DSPS is to be the estimated weight of the yacht as presented for racing, in pounds, excluding crew weight. For yachts that are primarily raced and daysailed, this is similar to 'light ship' (empty tanks, with minimal food and gear). For yachts that are equipped and provisioned for cruising while racing, this is similar to 'half load' (tanks half full, with ordinary food and gear) .
11	Rated Draft (RD) deeper than Base Draft (BD) speeds up rating
12	Base Draft (BD) is based on a second order polynomial fit to draft vs length across the Classic fleet
12	DM=maximum fixed draft.
13	DMcb=max centerboard down draft. CRF 2023 rates centerboard boats for 60% of the added depth of the board extension below the fixed draft
14	Length/beam ratio higher than base (for a long, narrow hull) speeds up rating
15	Base Length/Beam Ratio (BLBR) is based on a second order polynomial fit to LOA/Bmax ratios across the Classic fleet
16	Stability is a primary driver of sailboat performance potential, but physically measuring it is not a reasonable or practical logistical and cost hurdle to impose on the Classic fleet. Short of actual stabilitiy measurement, the next best thing is to influence ratings via stability that is calculated rather than measured. Higher calculated stability does result in a faster CRF rating, but the effect is kept modest due to the limited input data.
17	Calculated stability (RmTot) that is higher than base stability (RmBase) speeds up rating

18	If ballast weight is uncertain or unknown, a value is assigned that is typically 0.4*DSPS
19	RmTot = Calculated stability including effect of crew weight
20	VCG of net construction weight (DSPS - Ballast). Empirically derived
21	The crew moment arm for contemporary boats with broad beam aft is greater than it is for typical Classic hulls.
22	Crew count assumes an average crew weight of 185 pounds.
23	Calculated crew weight taken from a recognized IMS formulation
24	Base RM includes crew weight, and is based on a second order polynomial fit to Rmtot vs a function of Bmax and L across the Classic fleet
25	High stability (RMTot >RMBase) speeds up rating
26	The rating in decimal feet reflects speed potential as implied by the square root of an effective sailing Length.
27	Sec/mi, normalized to typical PHRF handicaps w/scratch R=100
28	Sec/mi, normalized to VPP GPH ratings, eg via ORCi or ORR
29	See table of assigned factors
30	A Disp/length ratio lower than base (long, light boat) speeds up rating
31	The Base DLF is is based on a second order polynomial fit to data that reflects the Disp/L distribution across the Classic fleet
32	A SA/Disp ratio higher than base (high power to weight ratio) speeds up rating
33	The Base SaDF is based on a second order polynomial fit to data that reflects the SA/Disp distribution across the Classic fleet
34	See table of assigned keel typefactors. The factors used reflect the differences in appendage wetted area and aspect ratio, rudder efficiency, VCB and VCG associated with the various keel types.
35	See table of assigned spar material factors. The factors used reflect differences in stability and pitch moment of inertia associated with the different mast material types and number of masts.
36	The MAF addresses the advantages of a keel trim tab, and is taken from IOR.