

Empirical Evaluation of Extensions to No-Stop Limits for Deep Air Diving

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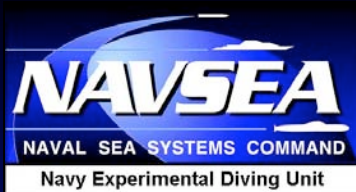
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Historical USN No-Stop Limits



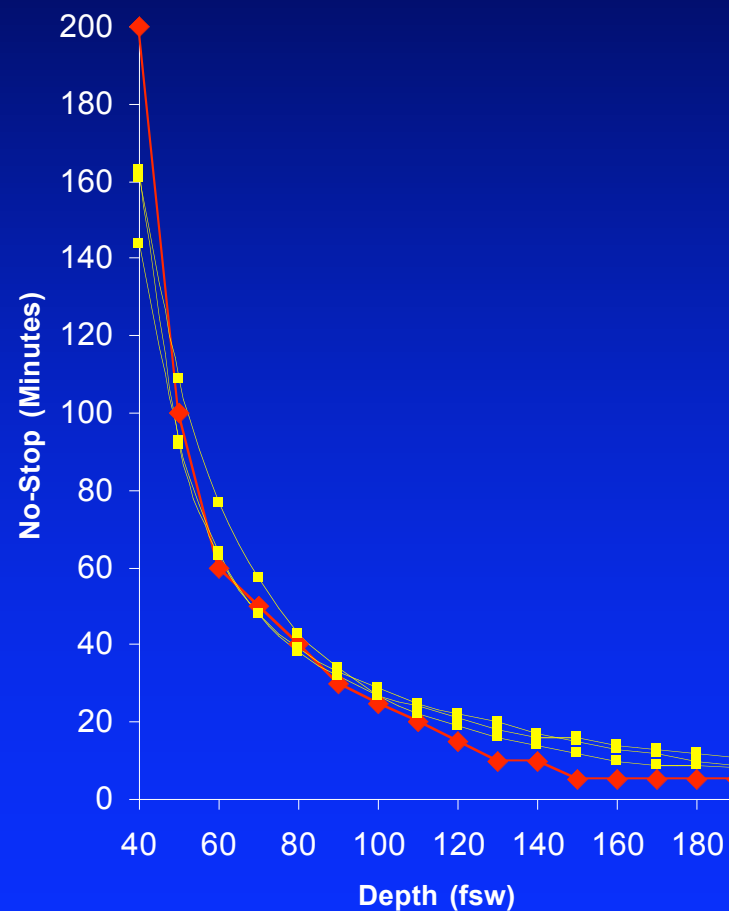
fsw	Haldane 1916	Std Deco 1943	USN56 1959
40	180	120	200
50	90	78	100
60	20	55	60
70	15	43	50
80		35	40
90		30	30
100		25	25
110		20	20
120		18	15
130		15	10
140			10
150			5
160			5
170			5
180			5
190			5



New No-Stop Limits

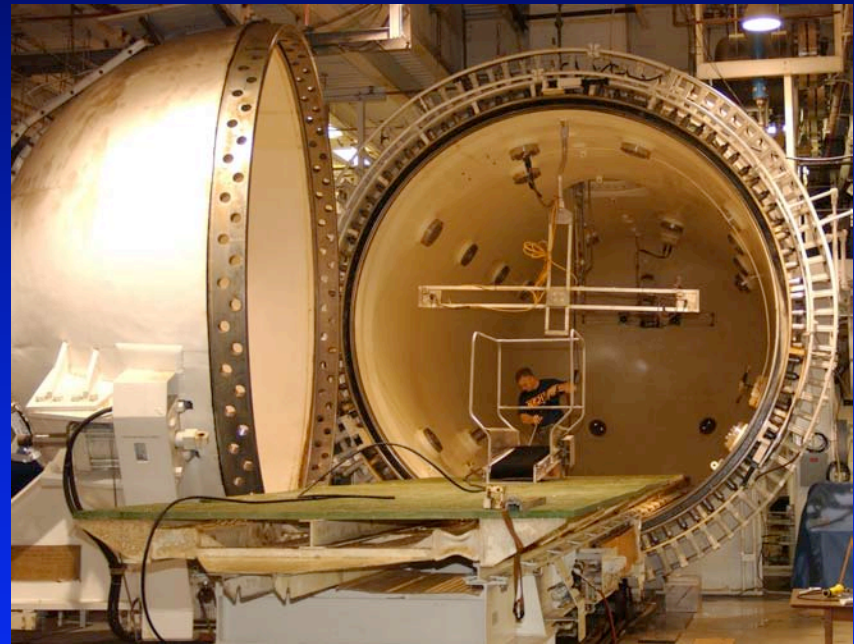


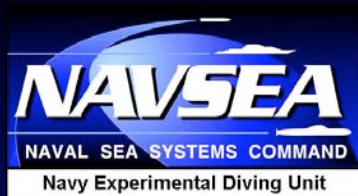
fsw	USN56	VVal-18	USN93 2.3%	BVM(3) 2.3%
40	200	163	144	161
50	100	92	93	109
60	60	63	64	77
70	50	48	48	57
80	40	39	38	43
90	30	33	32	34
100	25	29	27	27
110	20	25	24	22
120	15	22	21	19
130	10	20	18	16
140	10	17	16	14
150	5	15	16	12
160	5	13	14	10
170	5	12	13	9
180	5	10	12	9
190	5	9	11	8



Methods

- Selected limits tested for incidence of DCS
- 100 man-dives each
- sequential stopping rule of P_{DCS} exceeding 5% with 90% confidence.
- 89 divers
 - immersed in 55 °F (13 °C) water
 - 5–7 mm neoprene wet suits
 - surface-supplied air via full face masks
- 60 fsw/min compression, 30 fsw/min decompression
- 100 watt cycle ergometer work while on bottom

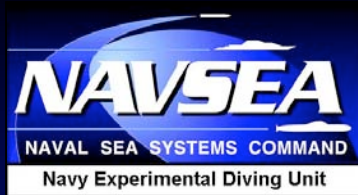




Results



Series	Depth/BT (fsw/min)	Prescribed by	Man- dives	DCS
A	130/20	VVal-18	84	2
	150/15	VVal-18	100	1
	190/11	USN93, 2.3% PDCS	100	1
B	130/16	BVM(3), 2.3% PDCS	57	0
	150/12	BVM(3), 2.3% PDCS	51	1
	190/9	VVal-18	40	1

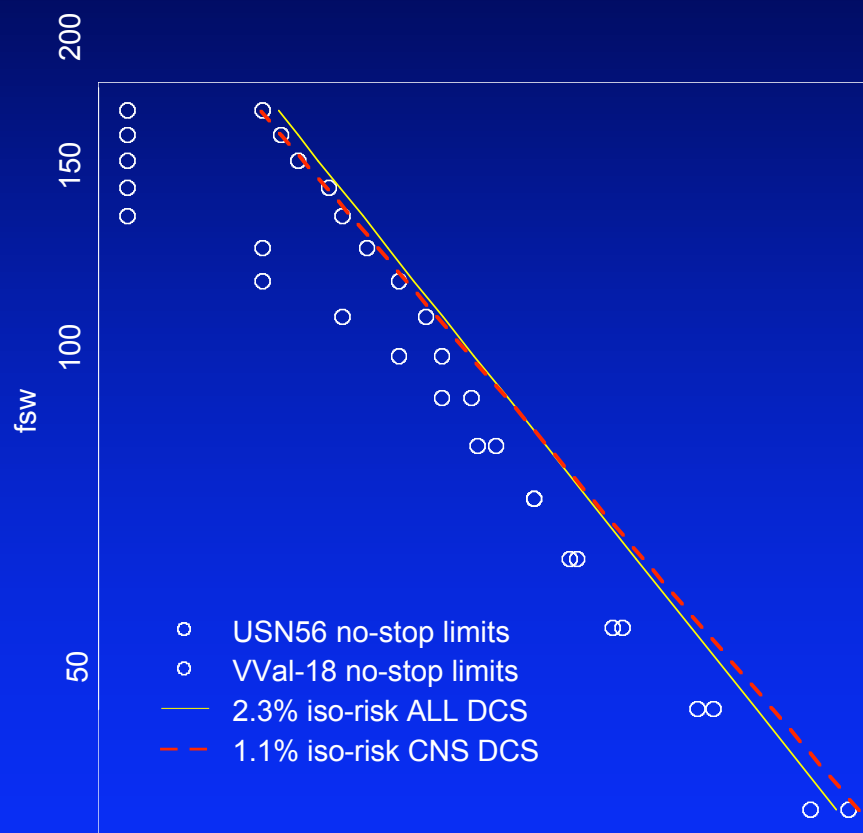


Brief Case Descriptions

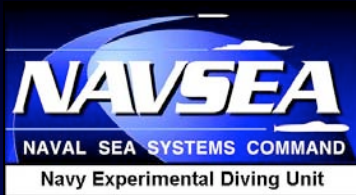
- “Heavy” legs, abdominal pain, numbness, paraesthesias, 40 minutes postdive
- Visual field deficit, 25 minutes postdive
- Right leg weakness and paraesthesia, balance difficulty, 20 minutes postdive. Recurrence of symptoms after first HBO treatment.
- “Heavy” legs, paraesthesias, progressing to paralysis below waist, 18 minutes postdive. Recurrence of symptoms after first HBO treatment
- Right hip pain and weakness, left flank pain, altered mental status, visual field deficit, balance difficulty, 10 minutes postdive
- Nausea, fatigue, dizziness, uncoordinated gait, altered mental status, blindness, 17 minutes postdive

Logistic Model

fsw	BT (min)	#	DCS	CNS
40-44	200-205	107	3	2
54-84	40-113	85	0	0
94	32-48	24	1	0
97-104	14-60	112	5	0
114	23-34	12	1	0
120-124	18-29	32	0	0
130-134	16-24	153	2	2
144	13-15	12	0	0
147-154	8-36	262	10	7
164-174	7-11	20	0	0
189-190	5-11	167	2	2
196-200	8-10	35	0	0
228-265	5-8	40	1	1
totals		1061	25 (2.4%)	14 (1.3%)



$$\ln\left(\frac{P_{DCS}}{1-P_{DCS}}\right) = \beta_0 + \beta_1 \ln(fsw) + \beta_2 \ln(BT)$$



Conclusions

- Extended no-stop limits tested resulted in a 1.1% incidence of CNS DCS.
- The severity of DCS makes the extended no-stop limits unacceptable for U.S. Navy diving.
- CNS DCS has generally occurred on schedules subject to extensive testing.
 - is a low incidence of unacceptably severe DCS a feature of no-stop limits?
- Testing of USN56 no-stop limits is in progress.

