KPM - MARINE

Seat safety

Latest developments
And regulation

A very quick guide

DRAFT

Marine seat design criteria

Human interface

- Anthropometric data base.
- Fit parameters
  - cushion dimensions
  - Seat height
  - Back rest width
  - Backrest height
  - Seat position
- Feel parameters
  - Pressure and shear
  - Temperature
  - Vibration transmission
- Support parameters
  - Lumbar support
  - Body segment angles.

Whole Body Vibration

- Understanding speed at sea
- Occupant injury recognition and reduction
- Occupant weight compensation
- Seating position and layout
- Mitigation capability

Crash testing.

- Crash test
- Static testing
- Homologation
- Escape measures.

Legal and Regulation

- MGN;353,436,HSC Code
- Annex 10
- Employment / statute law

Anthropometric data. Human Interface

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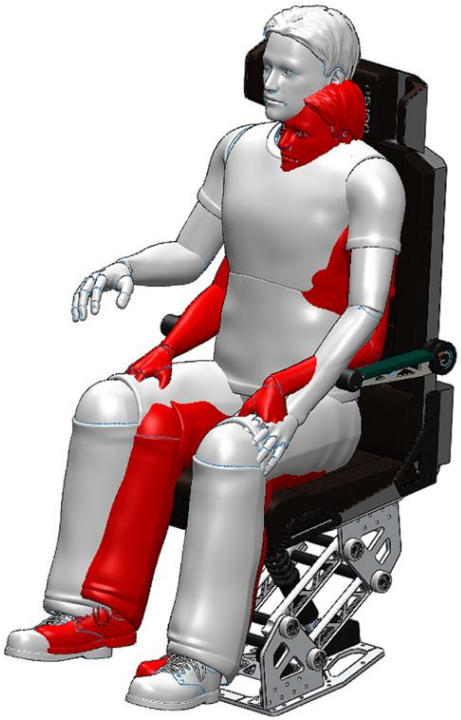


- Seat systems for Mass transit need to account for the 5th percentile female to the 95th percentile male.
- The seat size should account for the kit being worn
- Cushion depth and length should give the support but not create pressure points made worse but Vibration.
- No lateral obstruction from side bolster.
- Excessive moulding causes buttock hammock and destabilises the hip and spine.
- Back rest width must give full width and height support for a 95th percentile male.(not ¾ seat)
- There should be no lateral clearance restrictions (ie side bolsters)

Figures 5 and 6

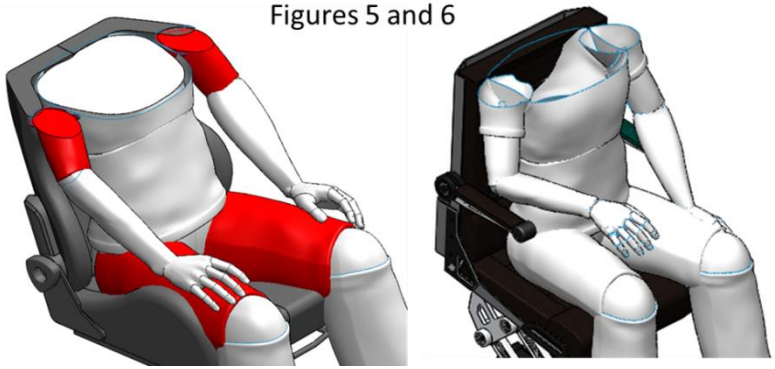
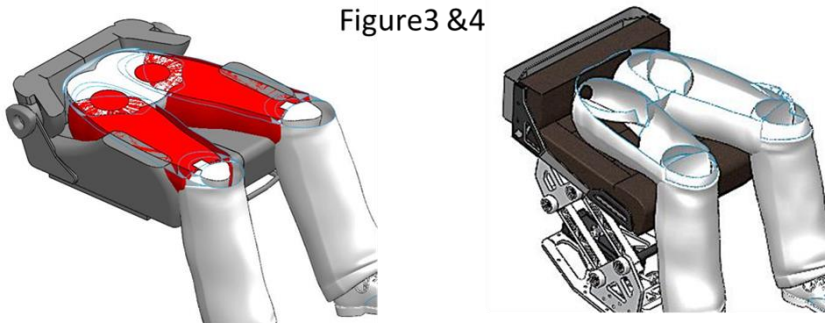


Figure3 &4



Leg splay ,movement and pressure distribution

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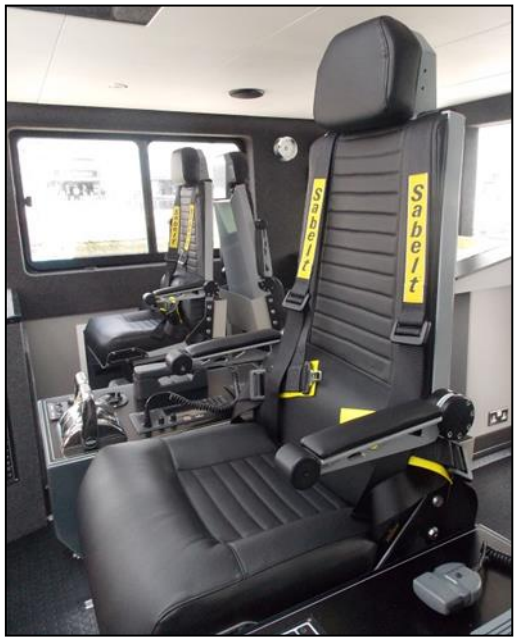
Marine (any) mass transit seats Need to be free from bolsters and restraints to allow movement of the occupant. Truck and Car seats are designed to have a confined operating area when operating pedals and have support bolsters , which cause pressure points

Seats should allow

- splay for occupant to gain comfort
- Space for normal seat activity with comfort.
- Ability to adjust posture to relieve pressure upon the
  - Bottom
  - Knees]
  - Spine
  - Upper and lower leg.

Seat bucket vs lumbar



KPM seat.

Bucket

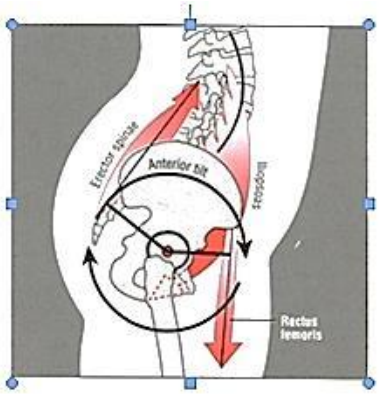
For marine seating with the motion of the vessel there is a tendency for the hip to rotate and slide out of the seats. This creates additional HIP back muscle activity. This can be reduced by

- **Increasing the bucket for the hip.**
- **Having a seat cushion angled >5 degrees from Horizontal..**

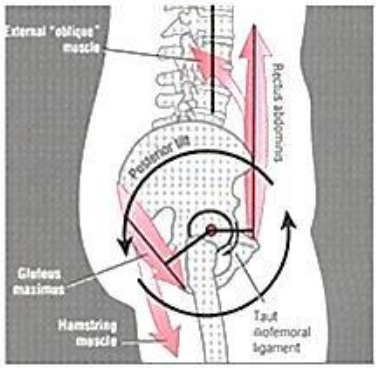
Lumbar

- **Lumbar support efficacy is debated and difficult to meet all body types.**
- **LBP can be reduced by the following**
  - **Increase in the backrest cushion angle vs cushion**
  - **The lumbar support used to support the hip**

Helicopter seat



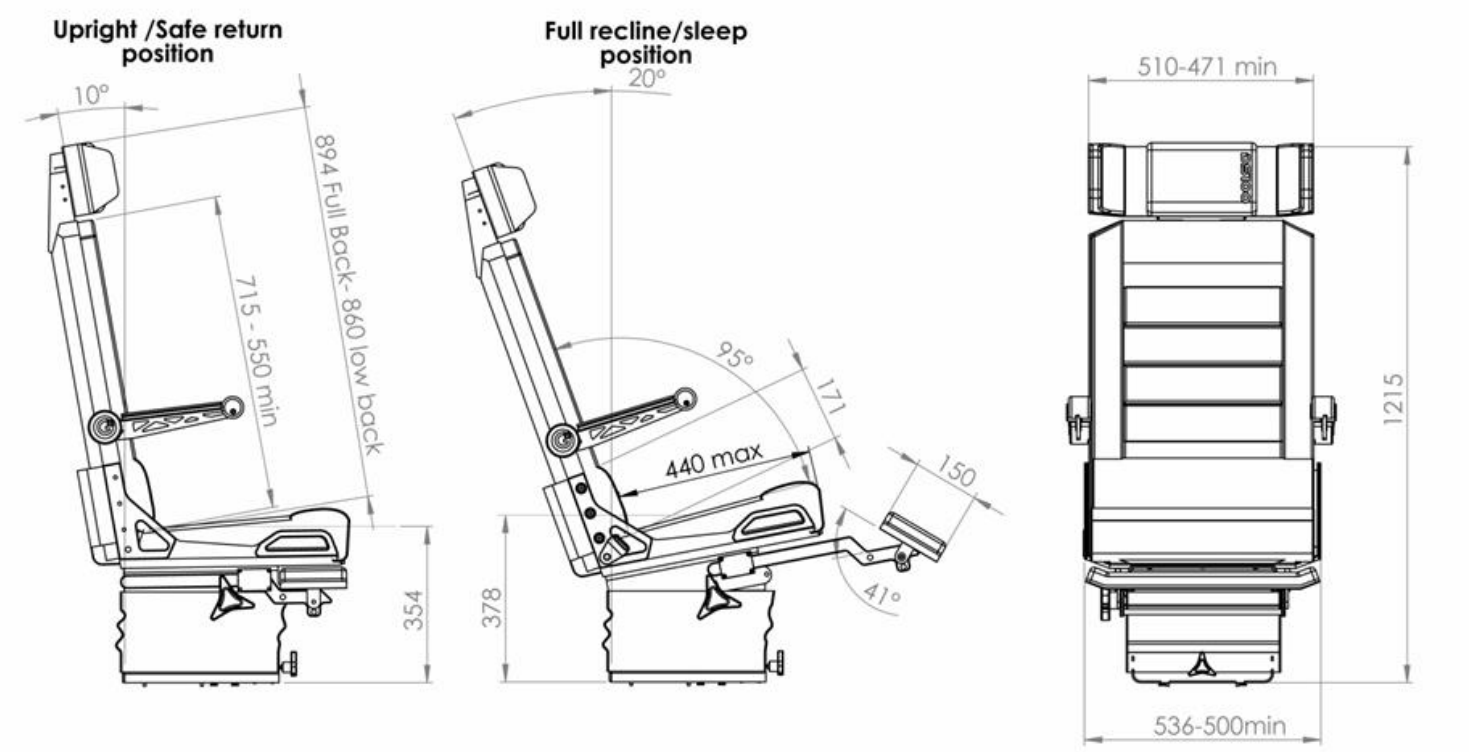
Anterior pelvic tilt



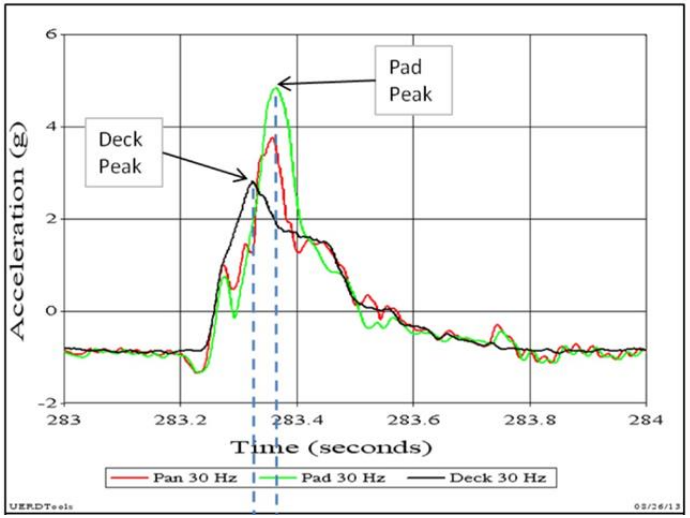
Posterior pelvic tilt

Seat dimensions, Body segment angles and seat adjustments

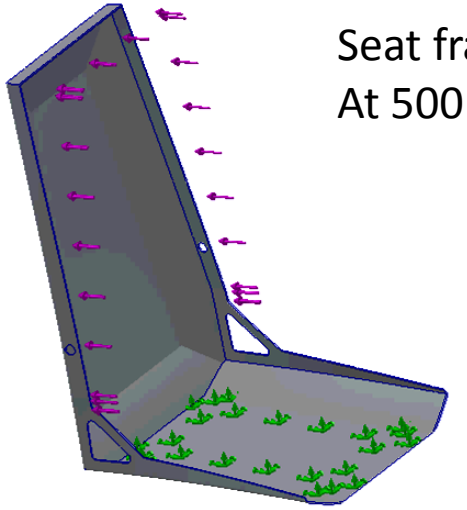
- **For marine seating the most significant is the trunk thigh angle and will reduce LBP.**
- **Knee angle and foot support will stabilise the hip and stop rotation caused by the motion of the sea.**
- **Reclining the trunk -thigh angle(95Deg) at an angle 20 degrees will reduce LBP in heavy sea state**



Transmitted seat vibration (not Impact)

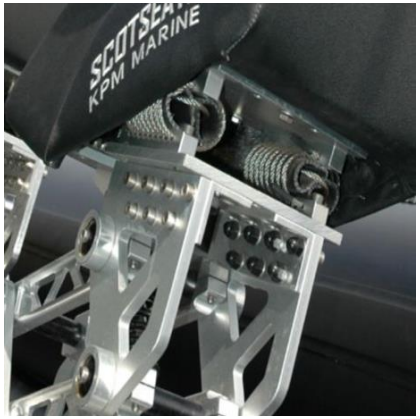


- **Soft upholstery can have a negative effect and amplify the g force.**
- **Soft upholstery causes spine/hip movement and offers no support for neutral spine**
- **Meat to metal**
- **Bolsters/moulding will attenuate forces to the body**
- **Firm cushion or HACS without bolsters**
- **Seat frame needs to remove TSV by compliance or Decoupling**



Seat frame compliance
At 500kg ie 100kg @5 G

Decoupling springs
on seat bottom



Whole body vibration

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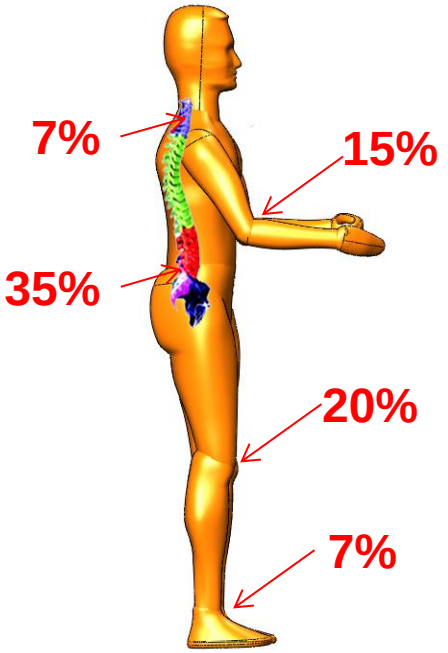
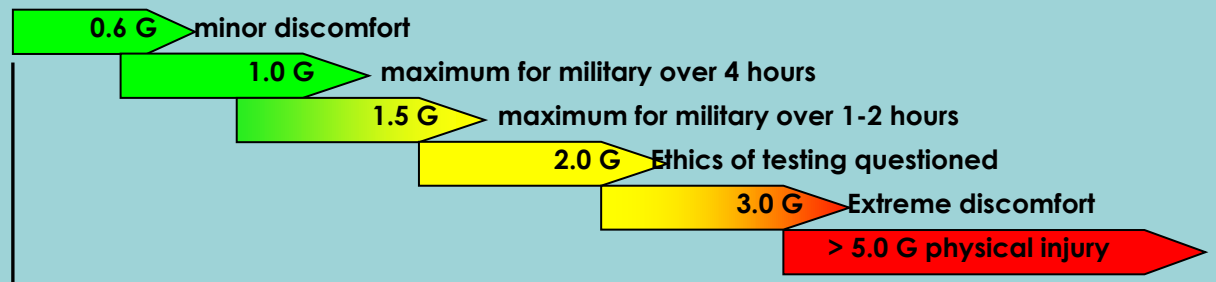
Variables	TSM Control	Results
HSC Sea keeping		Less Injury
Sea state		Less fatigue
Coxswain skill		Less motion sickness
Speed		Improved balance
Occupant		Occupant Security





Common Complaints of fast Boat occupant

- Cervical disc herniation
- Musculoskeletal disorders
- Lumbar disc herniation
- Repetitive strain Injury

Seats are last line of defence. If you are told it is the first then it is not true.

Occupant WBV effects

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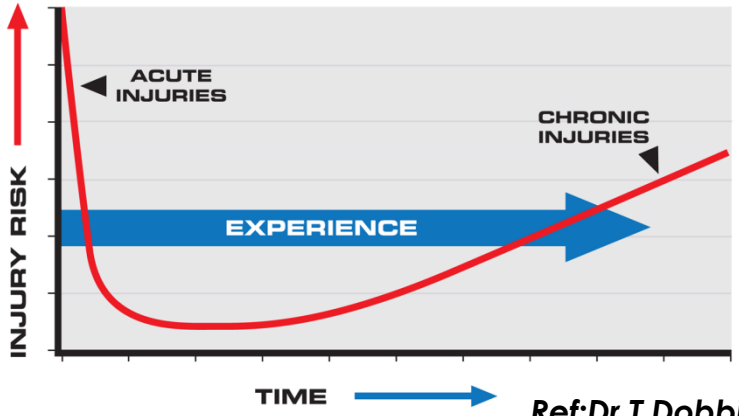
- Abdominal pain
- General feeling of discomfort ,including headaches
- Chest pain
- Nausea
- Loss of equilibrium (balance)
- Muscle contractions
- Shortness of breath
- Influence on speech
- Long-term exposure can cause serious health problems, particularly with the spine:
  - Disc displacement
  - Degenerative spinal changes
  - Lumbar scoliosis
  - Intervertebral disc disease
  - Degenerative disorders of the spine
  - Herniated discs
- Disorders of the gastrointestinal system
- Uro-genital systems

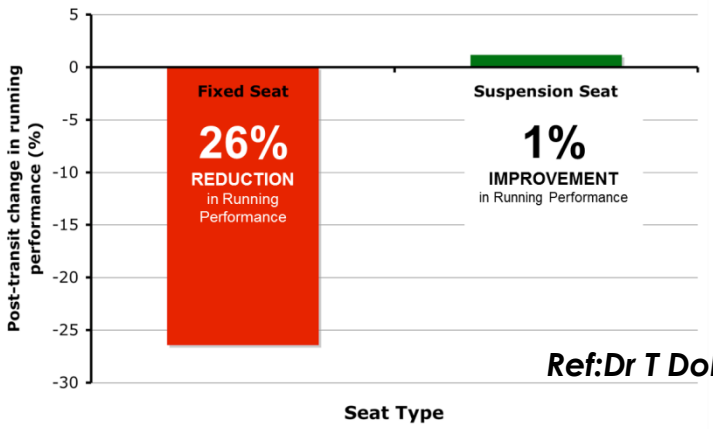
RACI

RISK OF ACUTE & CHRONIC INJURY



Ref:Dr T Dobbins

PAX FATIGUE



Ref:Dr T Dobbins

- **Train your crew to spot these symptoms**
- **Have an occupational health monitoring system in place**

KPM strongly recommend that the FRC WBV managers course is attended

From this date ALL EQUIPMENT needs to comply with EU Vibration Directive — July 2010

THE LEVEL OF EXPOSURE TO VIBRATION CAN BE REDUCED By incorporating preventive measures into work station design, by selecting suitable work equipment, by using methods and training to reduce the risks

You will not meet the EU regs but must be seen to have worked to best practice!

DIRECTIVE 2002/44/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

Seating positions

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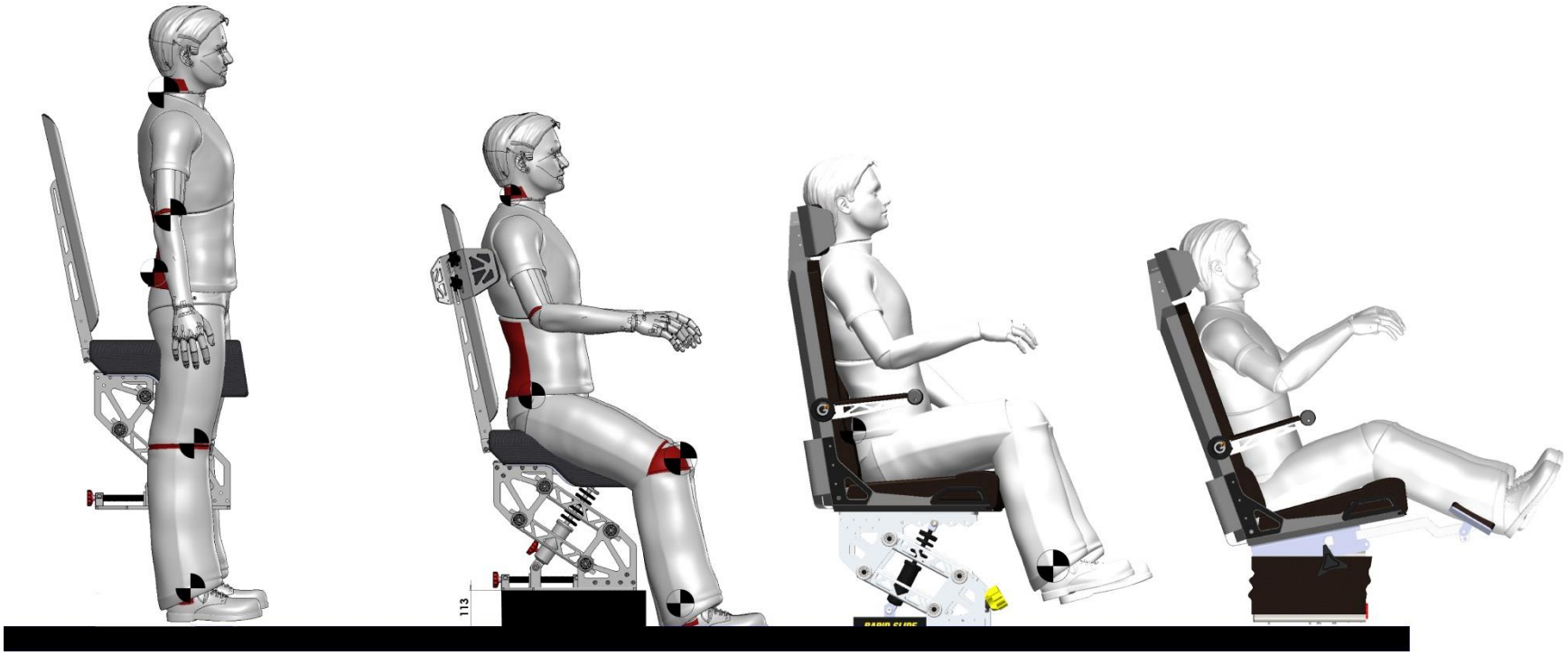

straddle intermediate full sit recumbent

Round 3 design

Reduction in fatigue for longer journeys

Seat Suspension action

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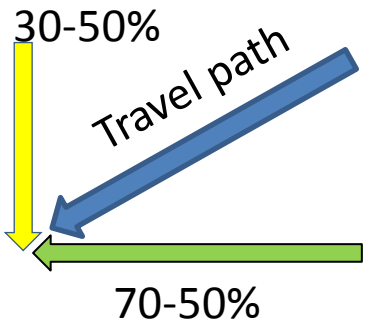
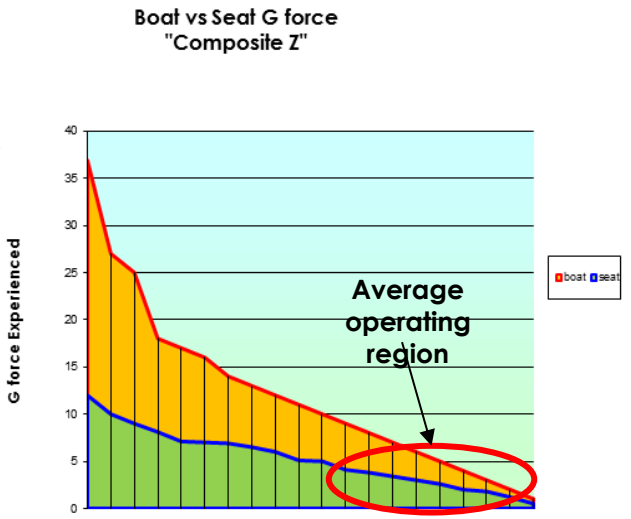
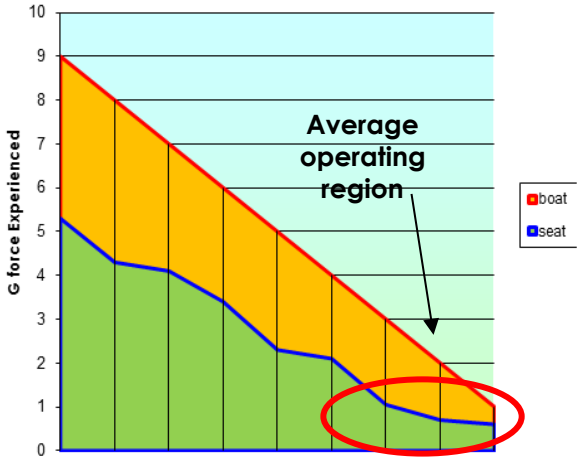
- **100mm is considered to be the minimum travel acceptable.**
- **Vertical suspension only takes out one force**







Ask your seat supplier for Capability of suspension and action and travel .

Typical Test session parameters

		Boat	Seat
Sea state: **1 – 6**	Max G	**49G**	**11.5G**
Speed: **0 - 50Knts**	Min G	**1.25G**	**0.45G**
Test time: **7 hours**	Averg	**2.09G**	**1.1G**
Wave events: **45,064**			

YOUR WEIGHT CHANGES AS SEA STATE DOES

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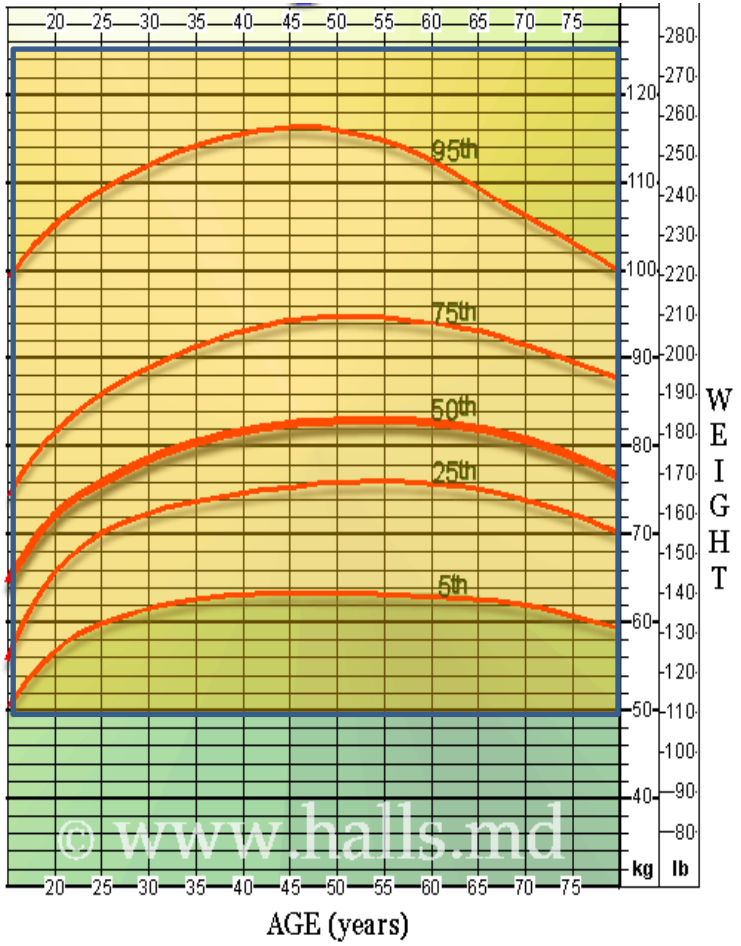
- All KPM seat suspensions for the Crew100 seats are now calibrated to the 5th to 95th percentile weight band setting. 80kg or100kg +/- 30kg for 3.0g
- In a study of suspension seats in use 70% were on the highest settings or the lowest settings. Since weight setting on the seat did not account for G forces at sea and bottomed out. Thus occupants locked them out.
- Occupants did not know or have training on how to set the seats .
- Suspension control handles are broken due to heavy use. Truck seat use do not have constant adjustment !
- Latest ISO standards and Military standards call for a 5th percentile female-95th percentile male weight.



Ask your seat supplier for details on Capability of suspension in sea states and weight ranges.

Seat Suspension classification

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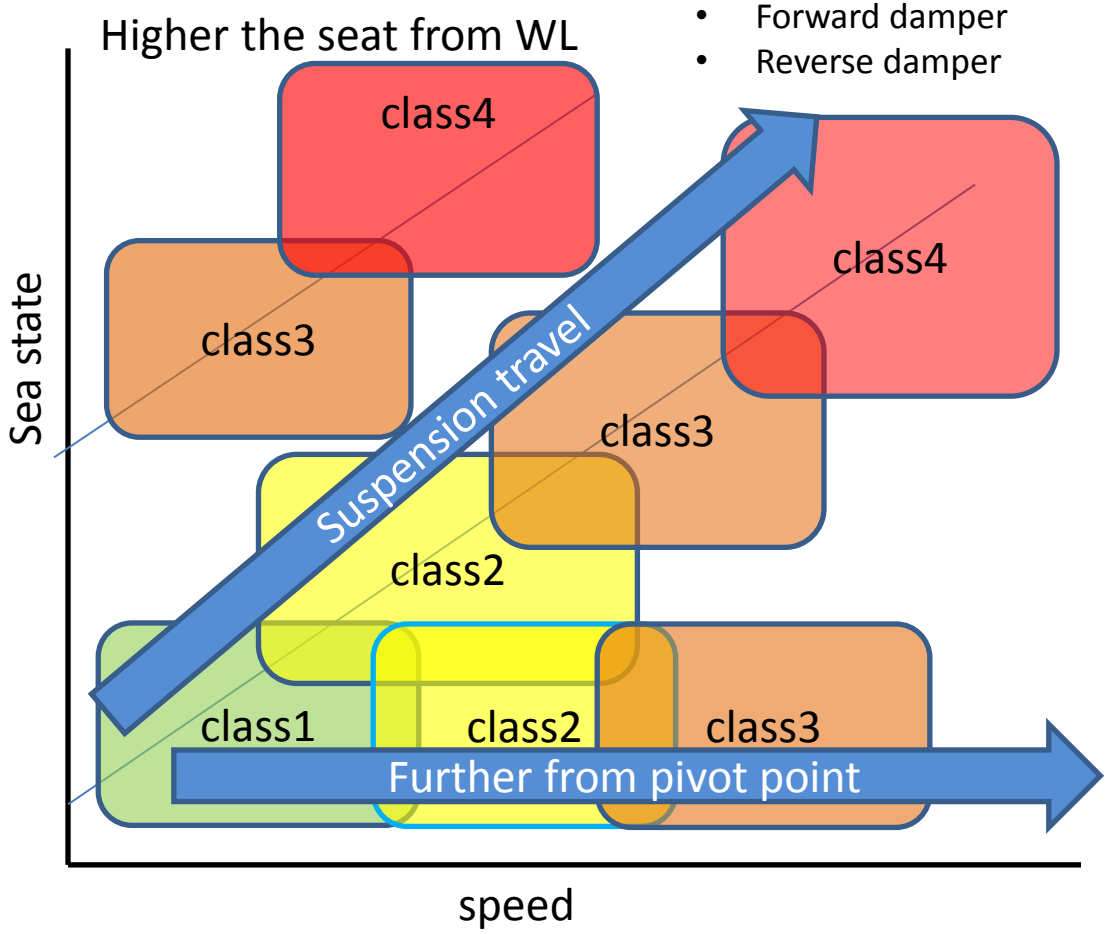
- TRAVEL100mm-250mm
- Forward damper
- Reverse damper



Ask your seat supplier for classification of seat and capability in different sea states and speed in different positions. Travel ,damping rate , tuneable . Etc.

Consider buying a WBV data logger
To understand your operating conditions,
Or KPM can do it for you.

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WHY IS CRASH TESTING IMPORTANT ?

There are four parts to Annex 10. (HSC Code)

- Dynamic tests
- Static tests
- Protrusion protection
- Escape measures

Or is it

More regulation I could do with out?

Crash statistics at sea

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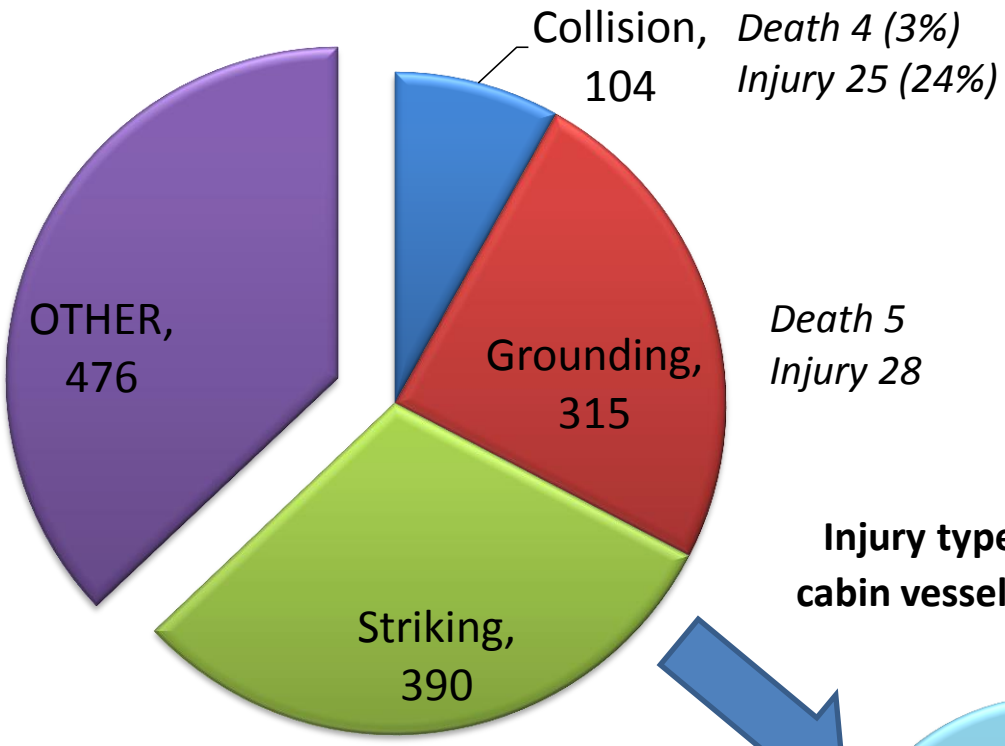
VESSEL INCEDENT BY TYPE 2001-2010

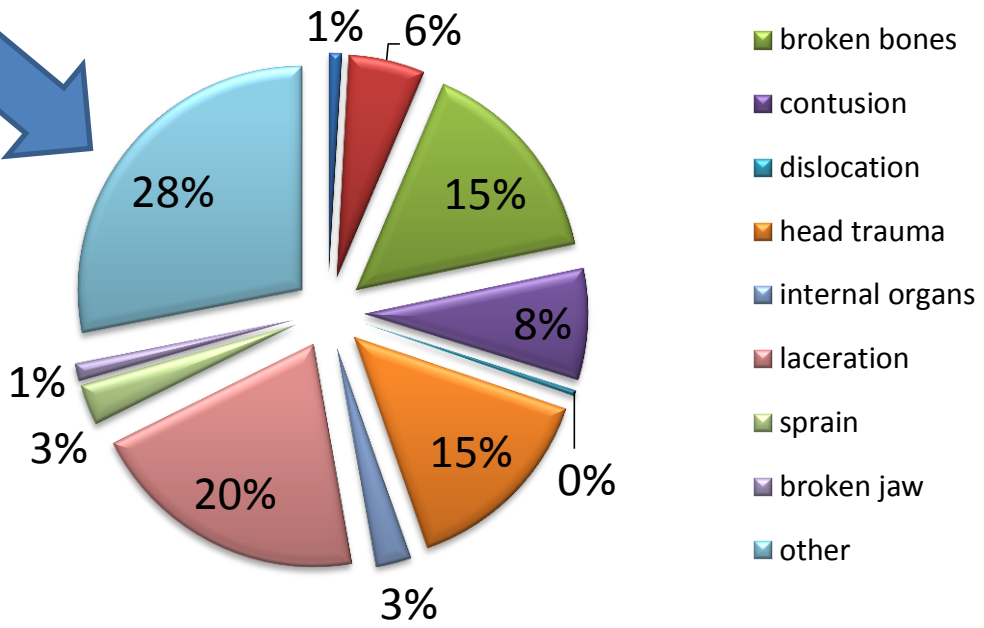


Transport Safety board Of Canada

Data includes

- Ferry; passenger , support vessels and Tugs
- Figures 2001-2010.
- Not including pleasure, fishing or ice events.

Injury type sustained in closed cabin vessel crew and passengers



Results between agencies correlate within 7%

USCG annual report. Average 2006-12

Crash statistics at sea

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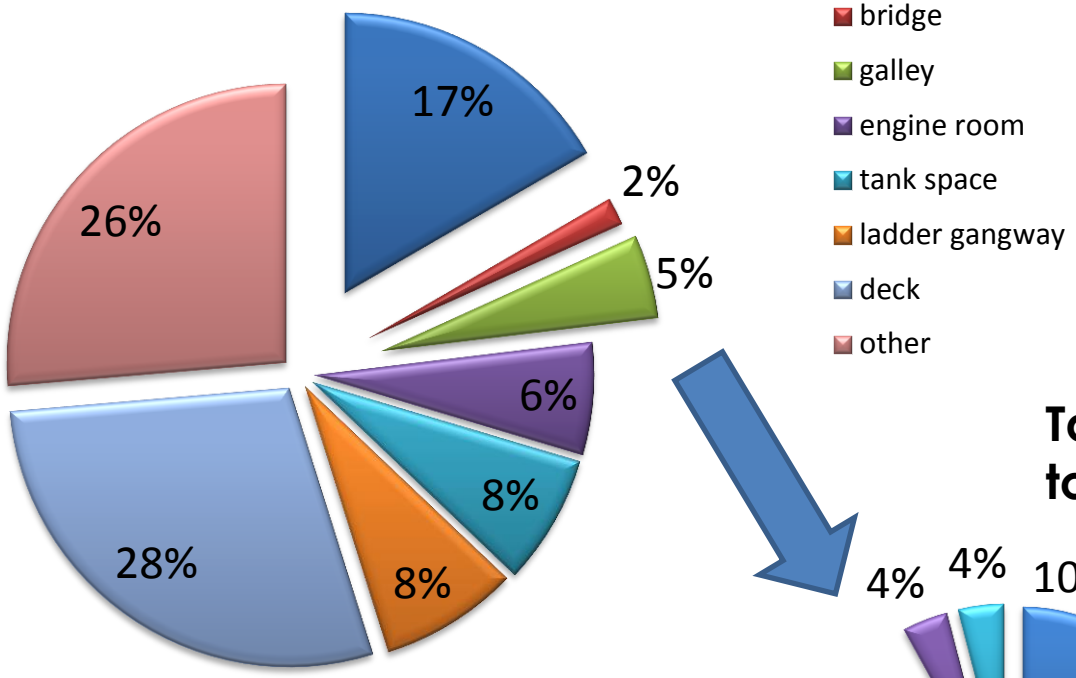
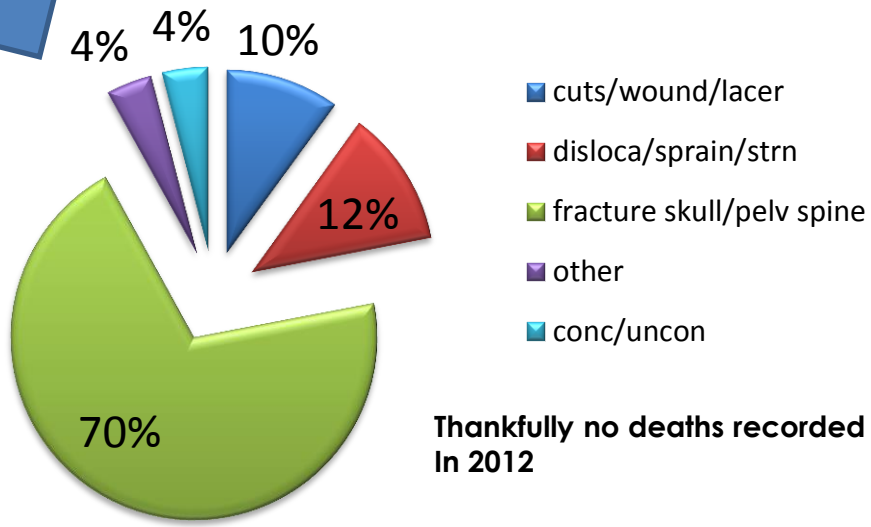
Table7; Deaths and injuries of MV Crew and place 2003-12



MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

MAIB annual report 2012 >100GT

Table11: Deaths and Injuries to Passengers by injury 2012



Thankfully no deaths recorded In 2012

Results between agencies correlate within 7%

Crash Testing and Annex 10

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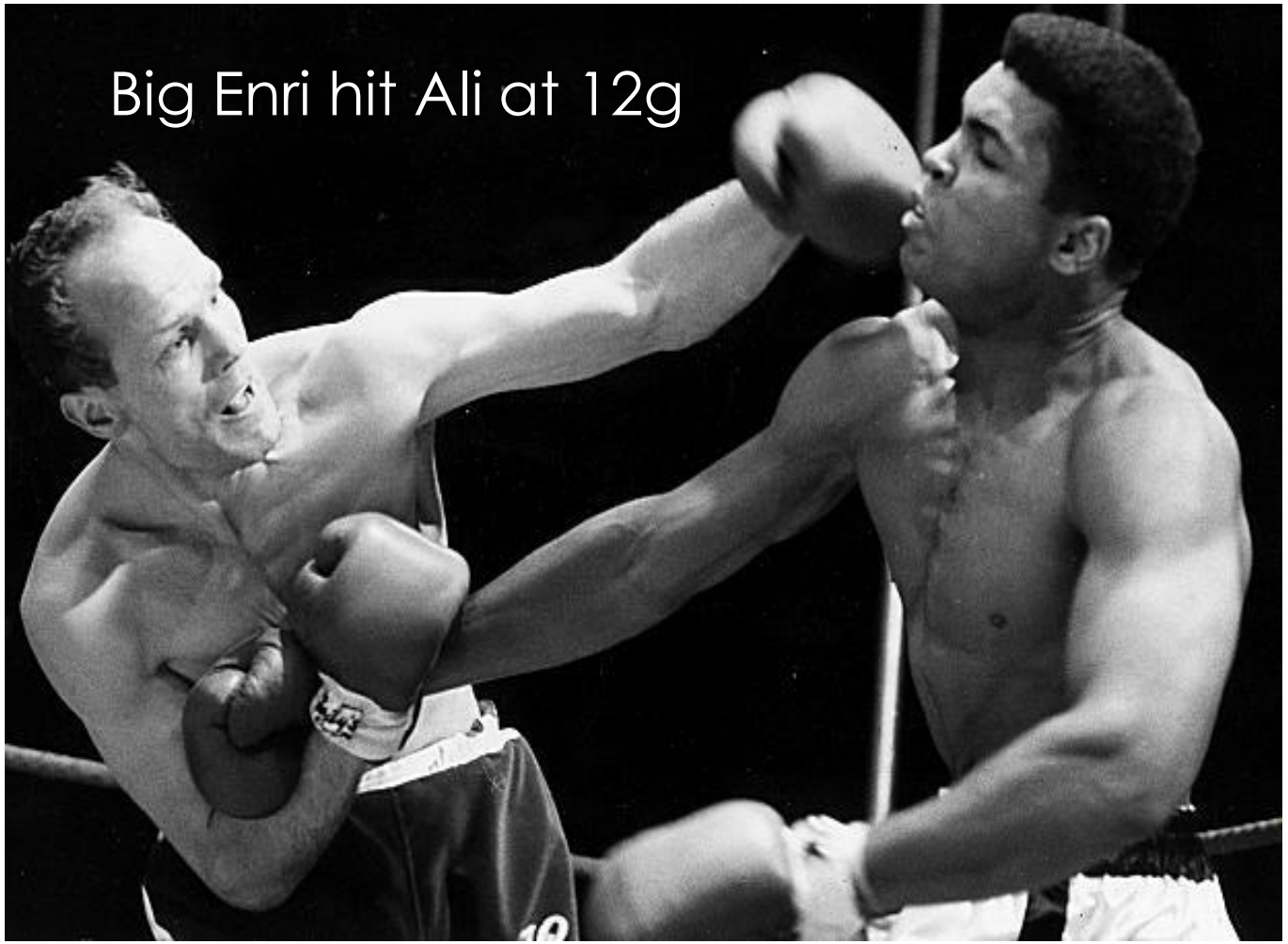
12 G ? It's Not how fast you go but how quickly you stop!!!



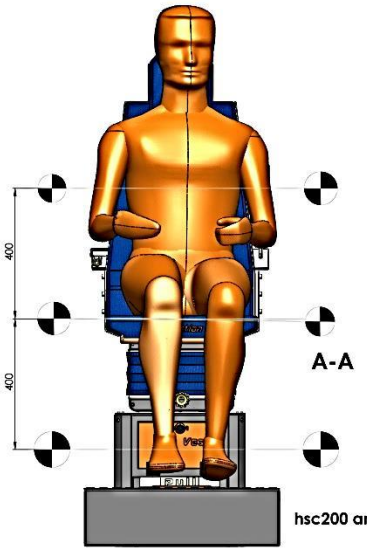
Q-DO I NEED 12 G SEATS

NO

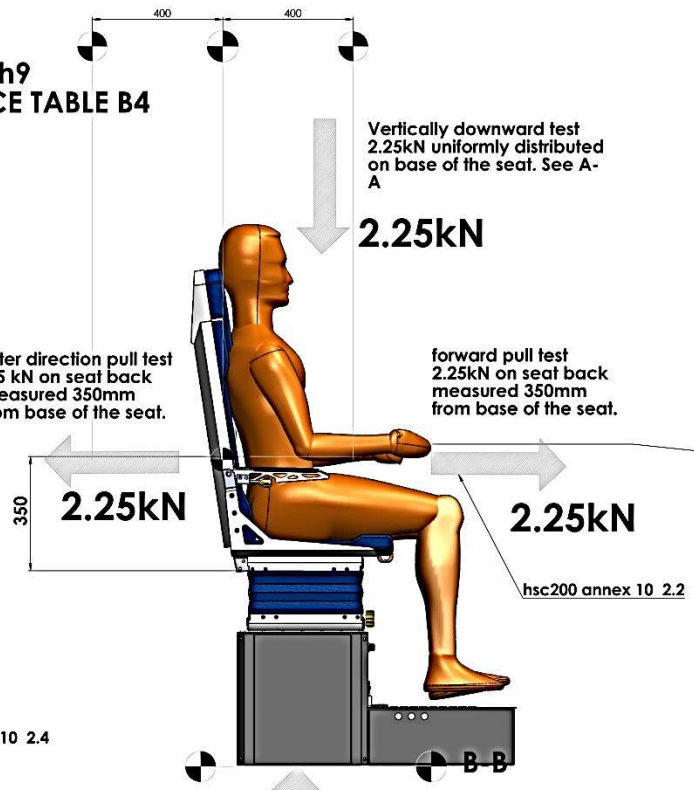
- **If you can prove that your vessel has a gcoll of 1-3g.**
- **If you can't then you need a 12 g seat to gcoll 3-12.**
- Remember 12 g is only 28mph or two vessels colliding at 14mph.

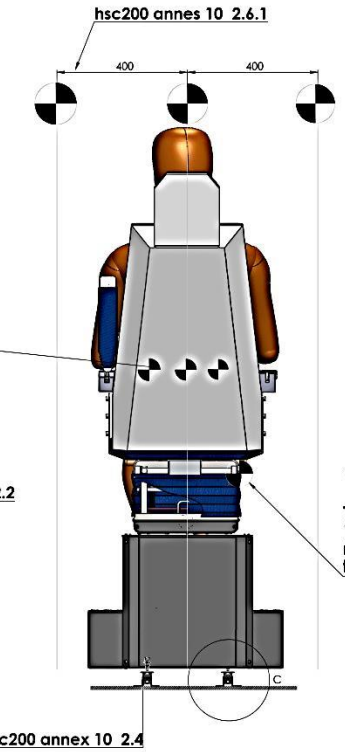
static tests

DNV Rules for high speed Pt5 Ch9
1A1HSLC-R2-WINDFARM SERVICE TABLE B4
core code refer to
HSC 2000 chapter 4 ;July 2011
HSC 2000 annex 10 2.4



hsc200 annes 10 2.4



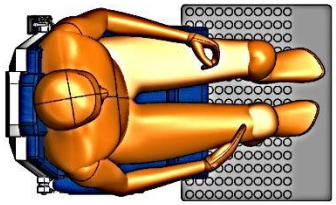


hsc200 annex 10 2.4

1.5kN

Transverse pull test
1.5kN on seat side
measured 0mm
from base of the seat.

1.5kN Inversion???



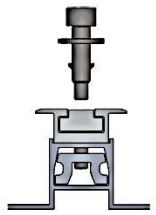
Test scope

- Each seating unit to be tested shall be attached to the support structure to the manner in which it will be connected to the deck structure in the craft. Although a rigid support structure can be used for these tests a support structure having the same strength and stiffness as the support structure in the craft must be used.

Pass Criteria HSC annex 10 2.6: 1-5
the seat will be considered acceptable if;

- Under the influence of the forces the permanent displacement measured from the point of application force is not more than 400mm
- No part of the seat, the seat mountings or accessories become completely detatched during the tests.
- The seat remains firmly held,even if one or more of the anchorages is partly detatched.
- all the locking systems remain locked during the entire test but the adjustment and locking systems need not be operational after the test.
- Rigid parts of the seat with which the occupant may come into contact shall present a curved surface of 5mm radius.Tested with a 80mm radius ball as per homologation tests.

TESTING AUTHORITY MMU



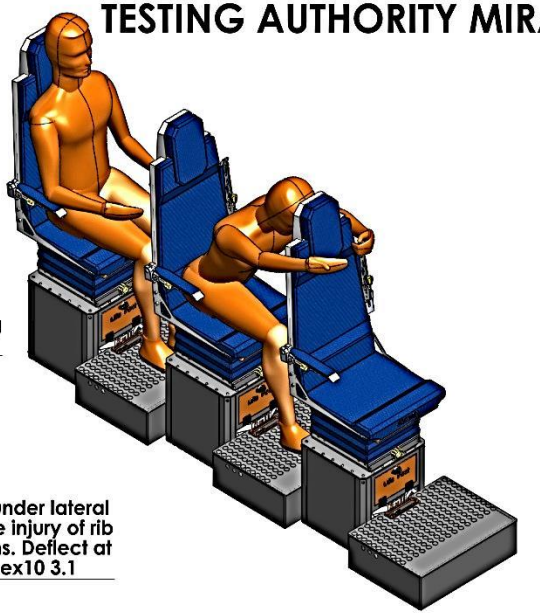
DETAIL C
SCALE 1 : 1

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS TOLERANCES: LINEAR ANGULAR		FINISH:			DEBUR AND BREAK SHARP EDGES	DO NOT SCALE DRAWING
						KPM-MARINE COPYRIGHT
	NAME	SIGNATURE	DATE			
DRAWN	JULES MORGAN					TITLE: static tests
CHK'D						
APPV'D						
MFG						
Q.A				MATERIAL		DWG NO. crash1
						A1
				WEIGHT:		SCALE: 1:10 SHEET 1 OF 4

Dynamic tests

DNV rules for High Speed Pt5 Ch9
1A1HSLC-R2-WINDFARM SERVICE TABLE B4
core code refer to
HSC 2000 chapter4 july 2011
HSC 2000 annex 10. 3.0

TESTING AUTHORITY MIRA



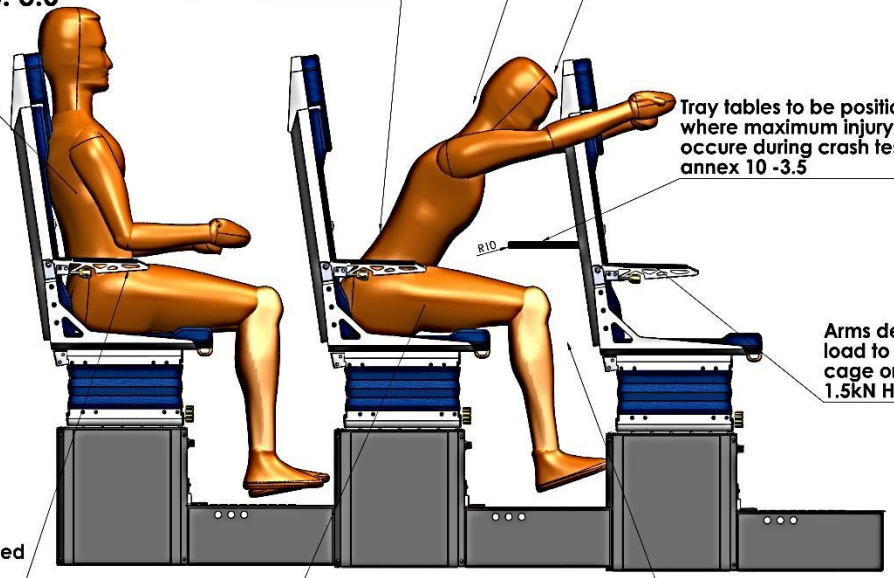
Extension and flexion of neck ref annex 10 3.6

head injury criteria less than 500 ref annex 10 3.9-1

Thoracic trauma index annex 3.9-3.2 3Gcoll or greater

Test dummy to annex10 3.6 or ISO 6487 Road Vehicles or SAE J211 Instrumentation

Tray tables to be positioned where maximum injury will occure during crash test of 3g annex 10 -3.5



Arms deflect under lateral load to reduce injury of rib cage or organs. Deflect at 1.5kN Hsc annex10 3.1

Gcoll 3G or greater

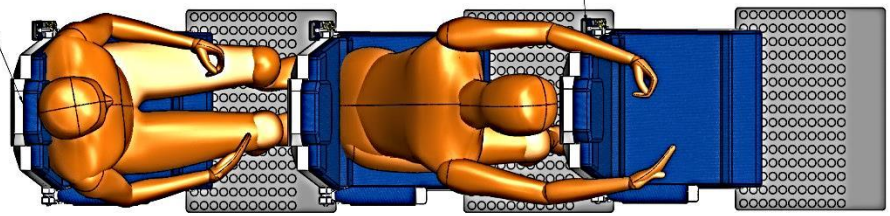
Load on lap belt not to exceed 7.8kN one handed release. HSC2000 4.61

Force on femur not to exceed 10kN or 8kN for 20mS or more Annex 10 sec3.6

Arms to be free of obstruction or traps

HSC Chapt 4-4.5.4 Attachments and structure should be of form and design to minimize trapping or injury

HSC 2000 Chat 4 4.4.5 Seats to be full length and support head with protective deformation or padding. seats are not to be half back



Thoracic trauma index annex 3.9-3.2 3Gcoll or greater

During test a 75 KG- 50th percentile dummy shall be placed in an upright position. If multiple seats are on one pedastle then all seat must have a test dummy.

Ref HSC 2000 annex 10 section 3.4 for the acceleration pulse and collision time history

Note!
dummy shown is 95 percentile 1.85M x 100kg

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KPM-MARINE COPYRIGHT

DRAWN: JULES MORGAN

TITLE: DYNAMIC TESTING

DWG NO: crash1

A1

What happens in crash test

- **Restrains should be worn**
- **Lap belts are no good with a table**
- **Intertia reels jam**
- **3 points do not work in side impact. Hence air bags in cars**

KPM full crash testing

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Good seat design is about predictability

KPM have tested all seats

KPM-MARINE

In 2011 South Boats Requested comprehensive Testing on all of their existing seats and configurations. The results instigated a redesign to meet the highest safety standards

Rear impact and floor failure

KPM SEAT SIMULATING FLOOR FAILURE

Results	KPM	Annex 10
HIC	29	500
Neck flex	1.46	88
Chest	11	30
Femur	219N	10,000N

Car and truck seats are not designed or tested for rear impact and should not be used in passenger applications

What happens if floor or pedestal is weak

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Dummy and seat travelled a further 5m

- All seats must be full size 860mm to top of head rest in lowest position
- Not half seat commonly used
- Note position of neck
- Combined weight of seat system and Dummy 175KG
- If the seat breaks away with person weight is 175KG x 12g =2100kg

Submarine and restraints ??

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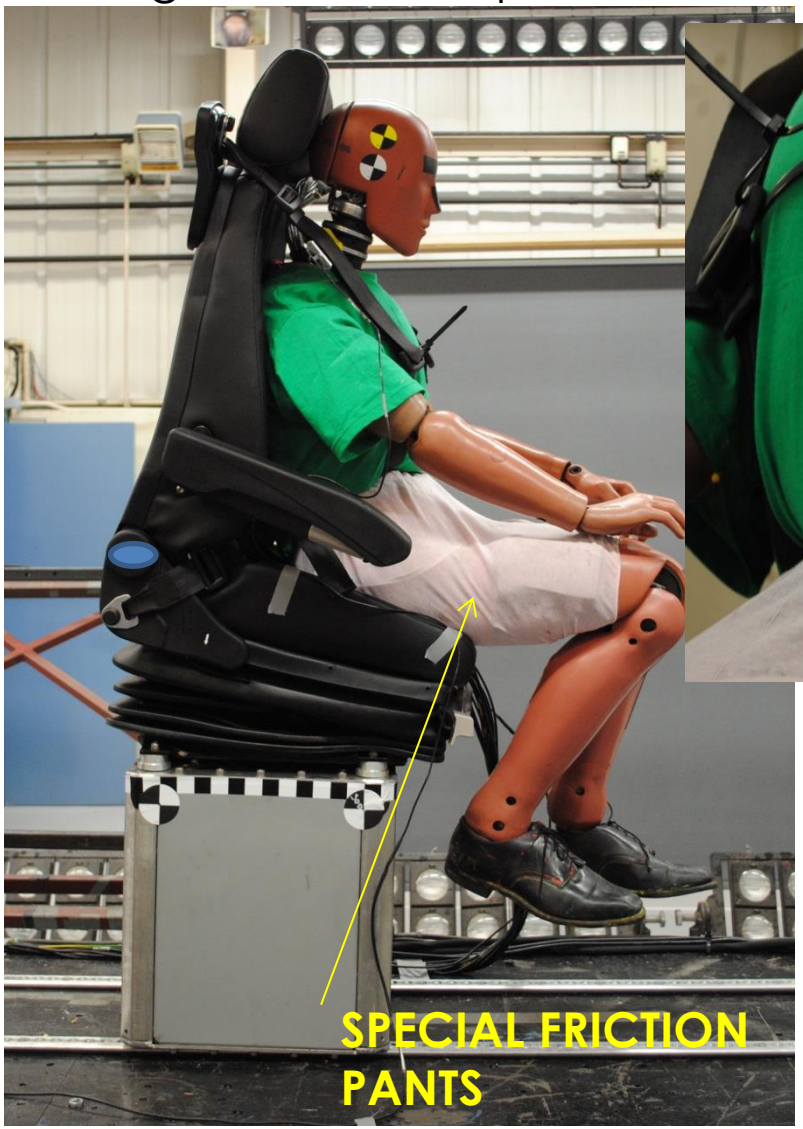
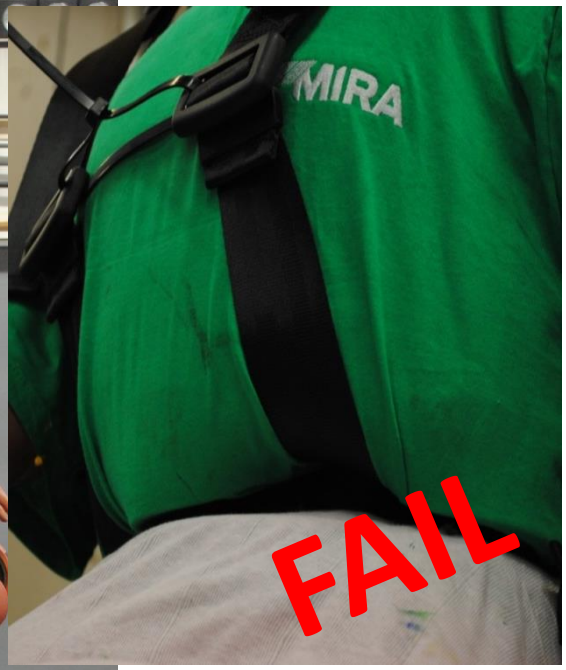
Existing seat on KPM pedestal and uni track tested by KPM marine





- **Lap belt/ harness under rib cage due to submarining.**
- **Fatal internal organ damage**
- **Lap belts should not be fitted.**
- **3 point harness only effective if head on collision -rollout.**
- **Inertia reel restraints fail at sea. Do not use them**

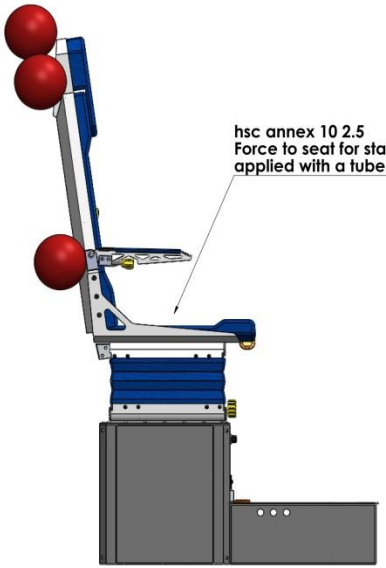
One of the biggest dangers surrounding lap belt injuries is paralysis. A lap belt injury is prone to hurting your internal organs, but because of the location, it is also dangerous to your spine

- Hyperextension of the neck, if it hits the seat in front
- Punctured internal organs, especially the bowel
- Broken vertebrae
- Dislocated vertebrae
- Spinal cord laceration
- Internal bleeding
- Muscle strain

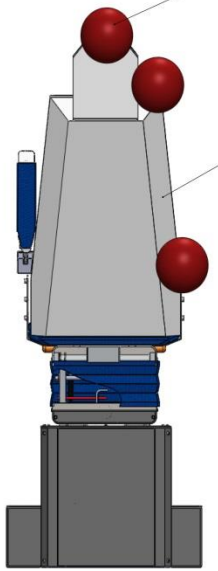
[5] D. Adomeit, Seat Design - A Significant Factor for Safety Belt Effectiveness, Institute of Automotive Engineering, Technical University Berlin (1979) SAE 79100 ; plus 20 other studies

Projection and contact surfaces

DNV rules for high speed Pt5 Ch9
1A1HSLC-R2-WINDFARM SERVICE TABLE B4
Core code refer to
HSC 2000 chapter 4 July 2011
HSC 2000 Annex 10 .



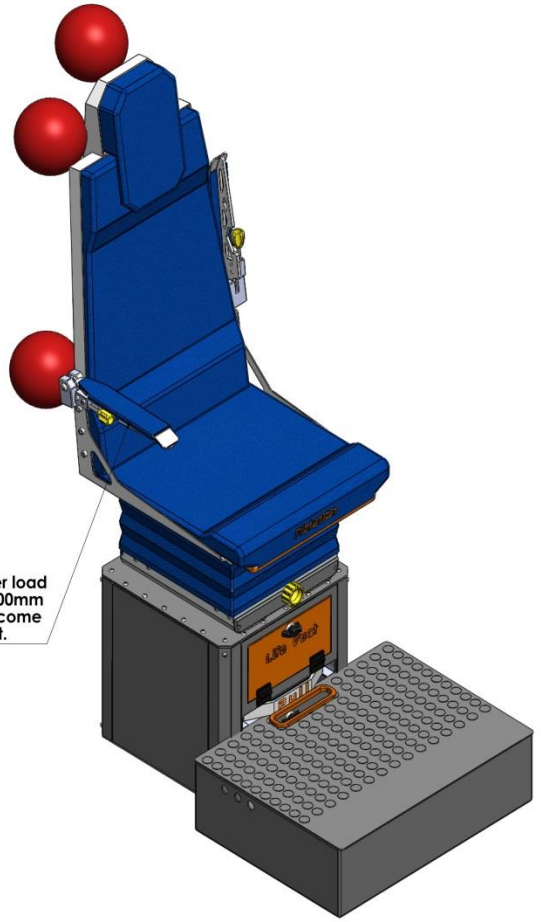
hsc annex 10 2.5
Force to seat for static test to be a applied with a tube of 80mm rad.



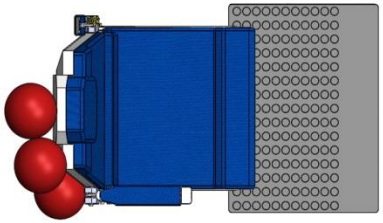
hsc annex 10 2.6
Ridgid parts of the seat that the occupant will make contact shall have a curved surface of mininmum 5mm Rad.

Test with 160mm Dia ball to evaluate head contact as per homologation regs.

Seat surfaces tapered to create deflection path.



hsc annex 10
Arm rests to be deformable under load whilst not deforming beyond a 400mm envelope. Arm rests must not become detached under a 3Gcoll impact.



KPM-MARINE

	NAME	SIGNATURE	DATE
DRAWN	jules morgan		
CHK'D			
APPV'D			
MFG			
Q.A			

MATERIAL:

WEIGHT:

DO NOT SCALE DRAWING | REVISION

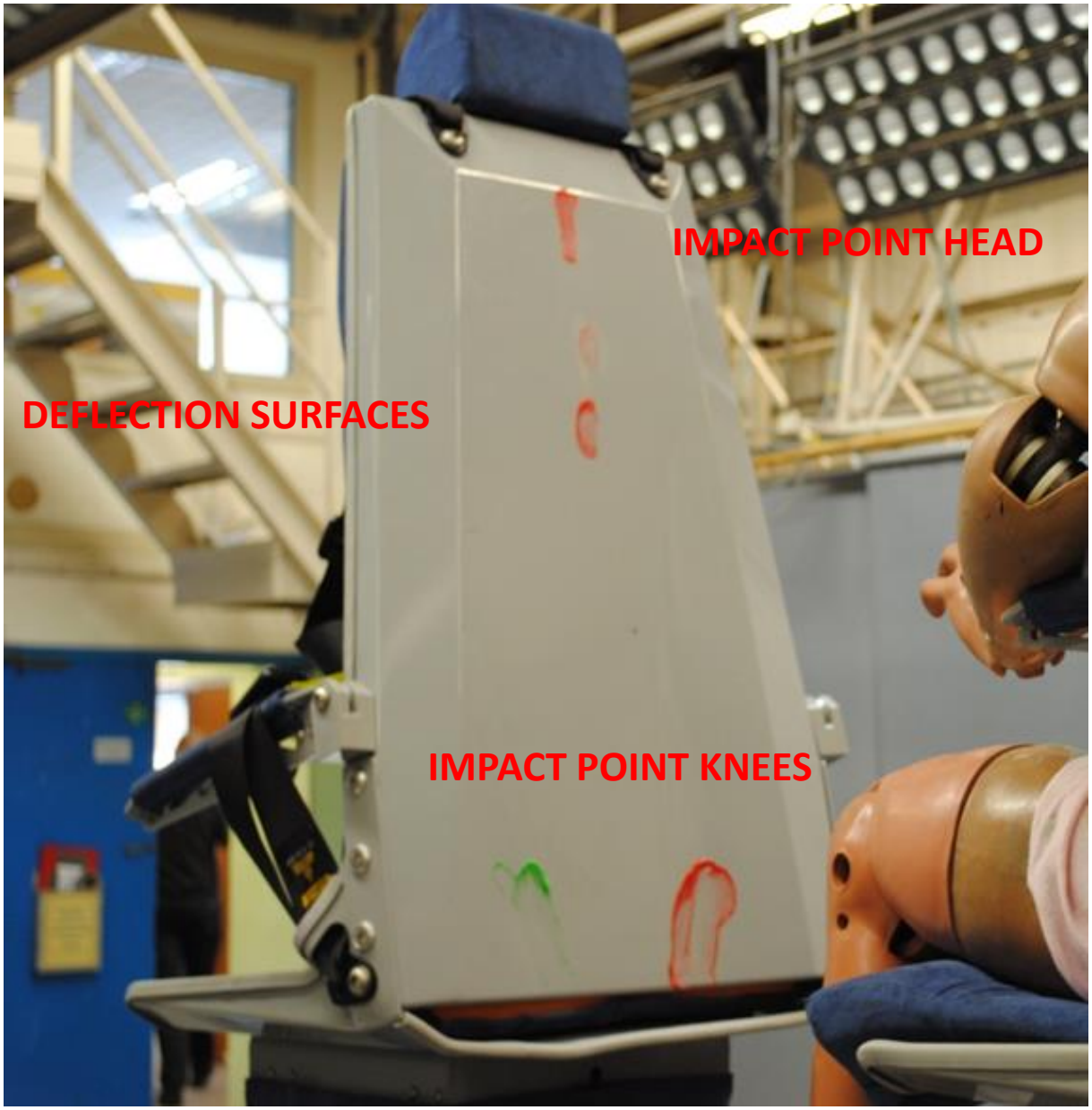
TITLE: Projection and surfaces

DWG NO: crash1 | A1

SCALE:1:10 | SHEET 3 OF 4

REAR PROTECTION

KPM-MARINE

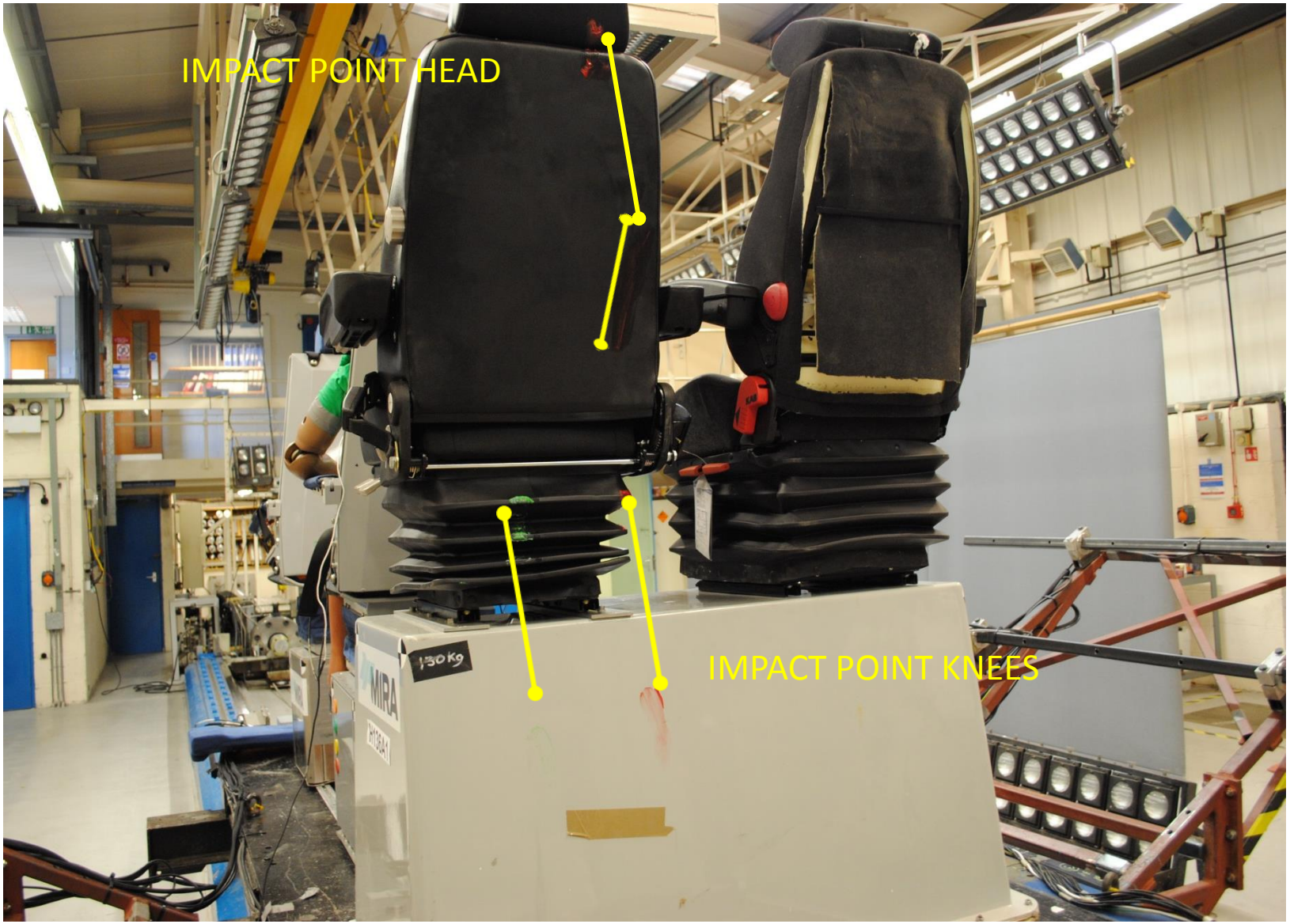


Results	KPM	Annex 10
HIC	29	500
Neck flex	1.46	88
Chest	11	30
Femur	219N	10,000N

- **Ensure that seat back is solid and able to withstand an impact**
- **Meat to Metal!!**
- **Ensure it is a full seat to eliminate head to head contact**

REAR PROTECTION

KPM-MARINE



Ensure seats are designed to take a rear impact.

KPM-MARINE

Head rest threw out a spike

- **Skull penetration and brain trauma**
- **Meat to metal**

- **Recline seat belt failure Broken** *(Industry known fault)*
- **Recline gear deforms or shears and collapses** *(Industry known fault)*
- **These parts rust in maritime conditions.**
- **Ref Ford monterey 230,000 recall;etc**
- **Toyota,Daewoo,Hyundai ,GM ;Porsche ,nissan ,GMC etc**

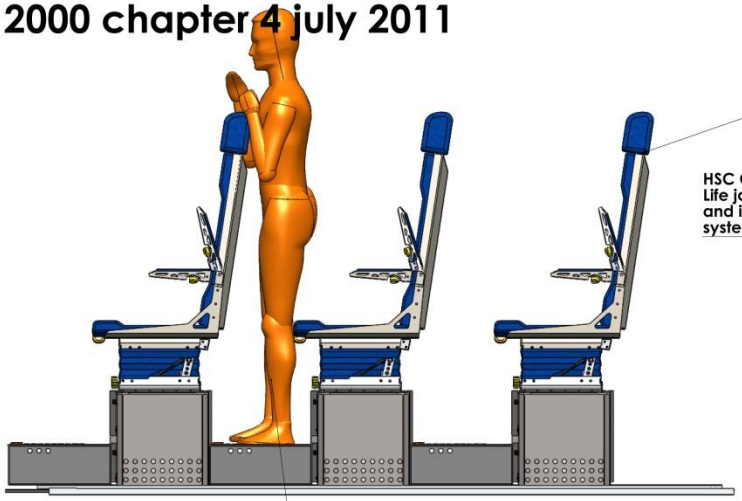
NOTE
Faults verified by a study of industry failure reports Please ask author for references

Note :Seats shown fit for intended use

Will the passengers alight safely

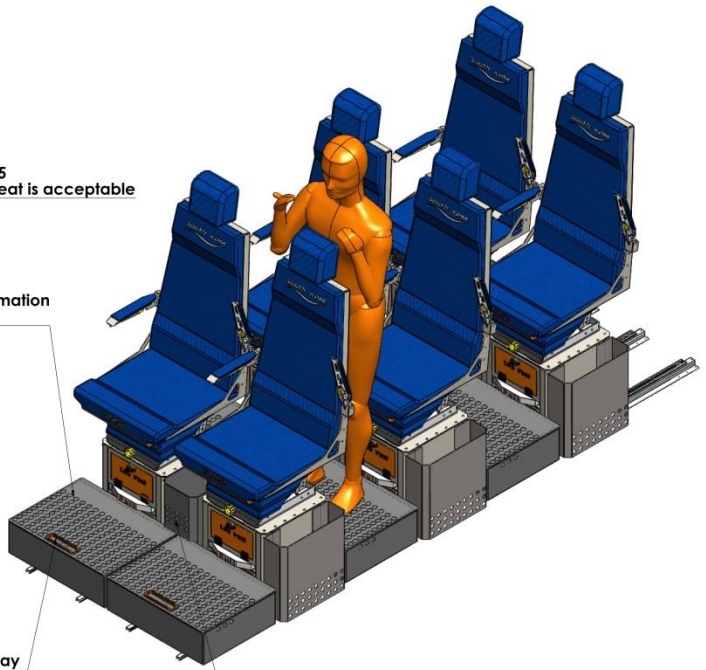
Accomodation and escape measures

DNV rules for high speed Pt5 Ch9
1A1HSLC-R2-WINDFARM SERVICE TABLE B4
core code refer to
HSC 2000 chapter 4 july 2011



HSC Code 2000 chpt 4 .45
Handholds to steady or seat is acceptable

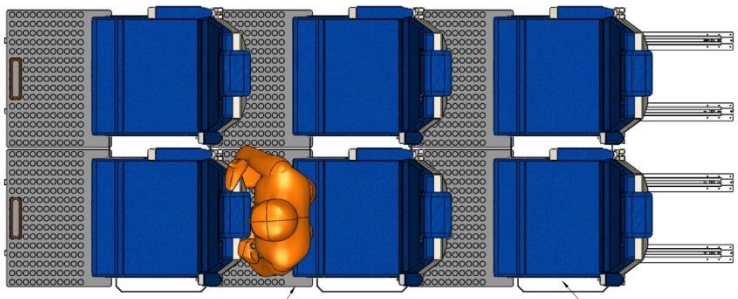
HSC Code 2000 chpt 4 7.3
Life jacket storage to be marked and illuminated or via video information system



HSC Code 2000 chpt 4 4.3
Seats must allow adequate access and not obstruct access to safety equipment

HSC Code 2000 chpt 4 4.4
Seats,life saving devices must not disloge under Gcol3 loads which may hinder rapid evacuation

HSC Code 2000 chpt 4 4.43
Equipment and baggage to be secured and remain in secured position whwn exposed to Gcoll 3 also ref chat4 4.9.1



HSC Code 2000 chapt 4 4.71
easy access in all operating conditions

HSC Code 2000 chpt 4 5.1
A seat must be supplied for each passenger and crew.

KPM-MARINE COPY RIGHT
JULES MORGAN
KPM-MARINE
ccomdation and escape
crash1

ESCAPE MEASURES AND STOWAGE

KPM-MARINE

- Ensure that safety equipment is still in place
- Ensure there are no escape blockages
- Ensure the ceiling does not collapse ,TV's , Kit , Coffee machines etc

1-Survive impact > 2-put on equipment > 3-evacuate to life raft

Hic 1539

Hic 159

Example of install

KPM-MARINE

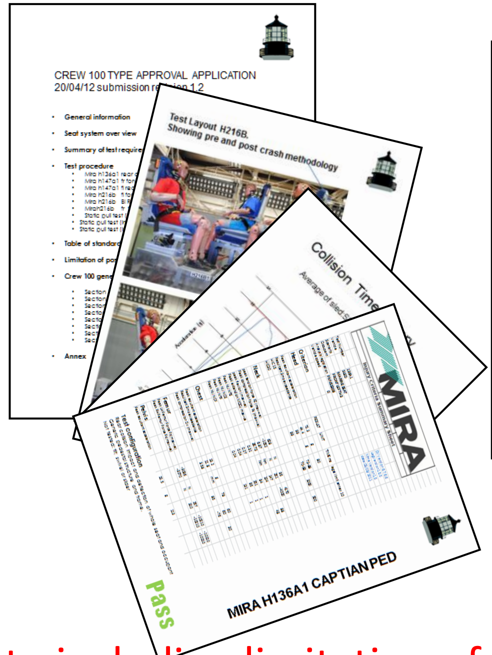
South Boats – KPM interior design after full design and crash test evaluation. Courtesy Sea Cat Services

Information you should ask for.

KPM-MARINE

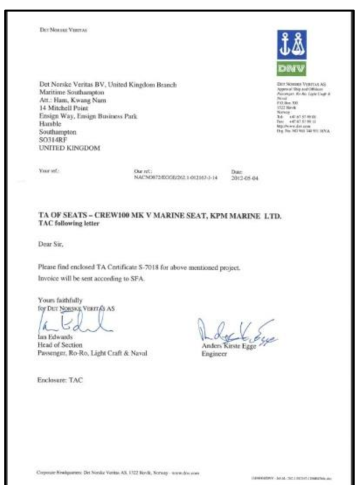
Full seat specification

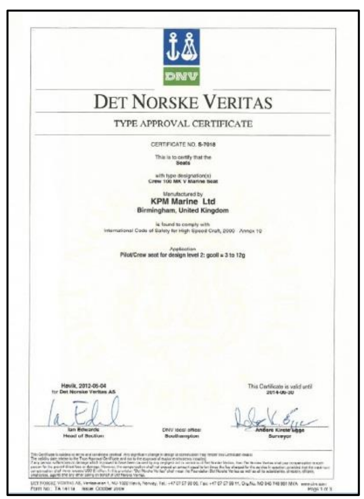
Full crash test info

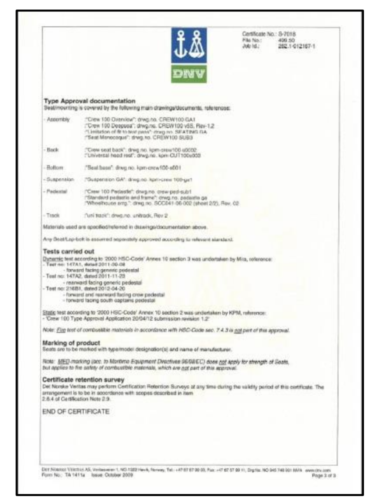


WBV details and data

Full seat Type approval Certificate including limitation of fit and accessories &TA scope







The Legal aspects and costs

KPM-MARINE

- **Neck whiplash** **£850-12000**
- **Collar bone** **£2500-£5000**
- **Leg fracture 2 year** **£5000**
- **Facial bone fractures** **£8650-£14000**
- **Front teeth** **£1300-£6600**
- **Facial scaring woman** **£1000-£56000**
- **Facial scarring man** **£1000-£38000**
- **Loss of sight one eye** **£28000-£32000**
- **Loss or hearing one ear** **£18000-£26500**
- **Minor back injury** **£7100**
- **Severe back injury** **£22000-£100,000**
- **Fractured arm** **£3800-£34800**
- **Loss of forearm** **£56000 -£63620**
- **Hip or pelvis injury** **£2100-£76000**
- **Amputation below the knee** **£5600-£82000**

The above do not include the loss of work compensation

- **Restraint and seat back failure £1,000,000-£30,000,000**

Depending on paralysis.

- **Recent test case where courts awarded a second compensation claim for increased time for rehabilitation.** *(RACI Curve slide10)*

- **The impact upon employers can be significant not only in relation to lost man hours, but also to potential civil, and criminal, liabilities (ref:http://www.maritimejournal.com/directory-entries/brodies-llp2)**

- **Specifiers; ie boat Builders or Naval Architects could be liable to prosecution not just boat owners or employers on the basis of design. Claiming adherence to MGN or Maritime regulations is of no barrier to Injury Lawyers**

KPM - MARINE

Thank you for Your time