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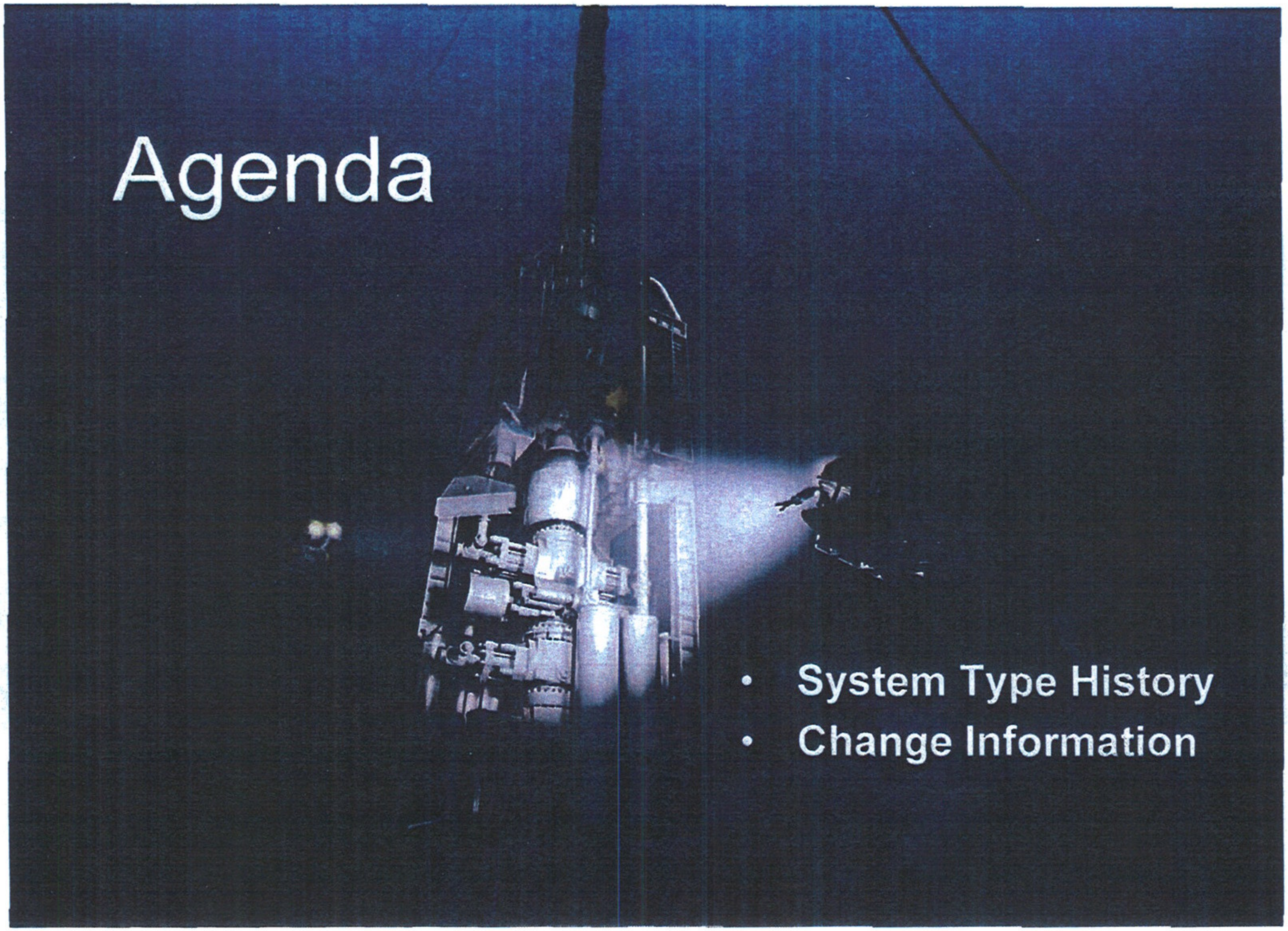
CAMERON

Mark III System Improvement Highlights

General Information

January 2010


Agenda
• System Type History
• Change Information

All of the Mark I & Mark II systems shown on this slide share the same general components, design and architecture. The difference between a Mark I and Mark II Pod is the footprint and number of functions, Mark I being square and Mark II being rectangular. All of the systems shown are still in operation today with the exception of P23. These systems were delivered on the dates shown.

Transocean	Leader	1997	Schahin	Lancer	1997
	Discoverer Enterprise	1999	Saipem	Scarabeo 5	1997
Sedco Forex	Sedco Express	1997	Ocean Rig	Leiv Eiriksson	1998
	Sedco Energy	1997		Eirik Raude	1998
	Cajun Express	1998	Pride	Pride Africa	1997
	Sovereign Explorer	1997		Pride Angola	1998
R&B Falcon	Peregrine III	1997		Pride Africa II	1997
	Deepwater Navigator (PVII)	1997	Marine Drilling	Marine 500 (PSP)	1997
	Deepwater Nautilus	1997		Marine 700 (PNA)	1997
	Deepwater Horizon	1997	Pride/Petrodrill	Pride Brazil	1998
Global Marine	Celtic Sea	1996		Pride Carlos Walter	1998
	Explorer	1996		Rio de Janerio	1998
	C.R. Luigs	1998		Pride Portland	1998
	Jack Ryan	1998	Petrobras	P23 (offline)	1997
Marinor/Stena	Stena Tay	1997	BP	Thunderhorse	2004
	Stena Don	1998			

31 Systems

The systems shown here are for the current "build cycle" beginning in 2006 and include some Mark I or 1.5 (a Mark I w/ additional functions) systems as noted. The balance are Mark III.

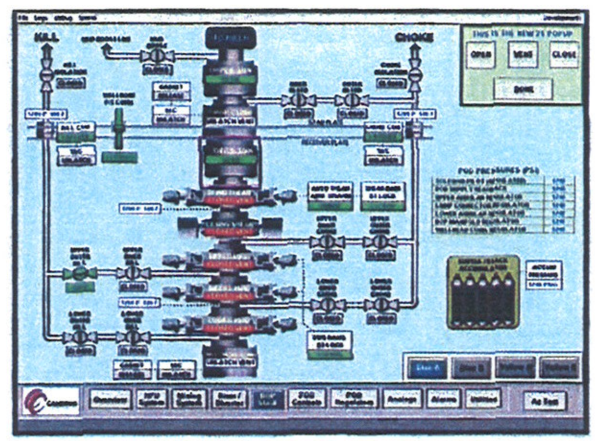
Stena DrillMAX I	Mark 1.5
Stena DrillMAX II	Mark 1.5
Sena DrillMAX I & II Spares	Mark 1.5
Stena DrillMAX III	Mark III Model 80
Stena DrillMAX III Spares	Mark III Model 80
Aker H6 Rig 1 - Spitsbergen	Mark III Model 120
Aker H6 Rig 2 - Barents	Mark III Model 120
Seadrill 13 – West Orion	Mark III Model 120
Aker H6 Rig 4 – Essar Wildcat / Neptune	Mark III Model 120
West E-Drill #1 – West Phoenix	Mark III Model 120
West E-Drill #2 – West Eminence	Mark III Model 120
PetroRig 1 – Diamond Ocean Courage	Mark III Model 120
PetroRig 2	Mark III Model 120
PetroRig 3	Mark III Model 120
Seadrill 8 – West Sirius	Mark III Model 120
Seadrill 9 – West Taurus	Mark III Model 120
Petro Rig 4 (Larsen)	Mark III Model 120

30 Systems + 9 Other

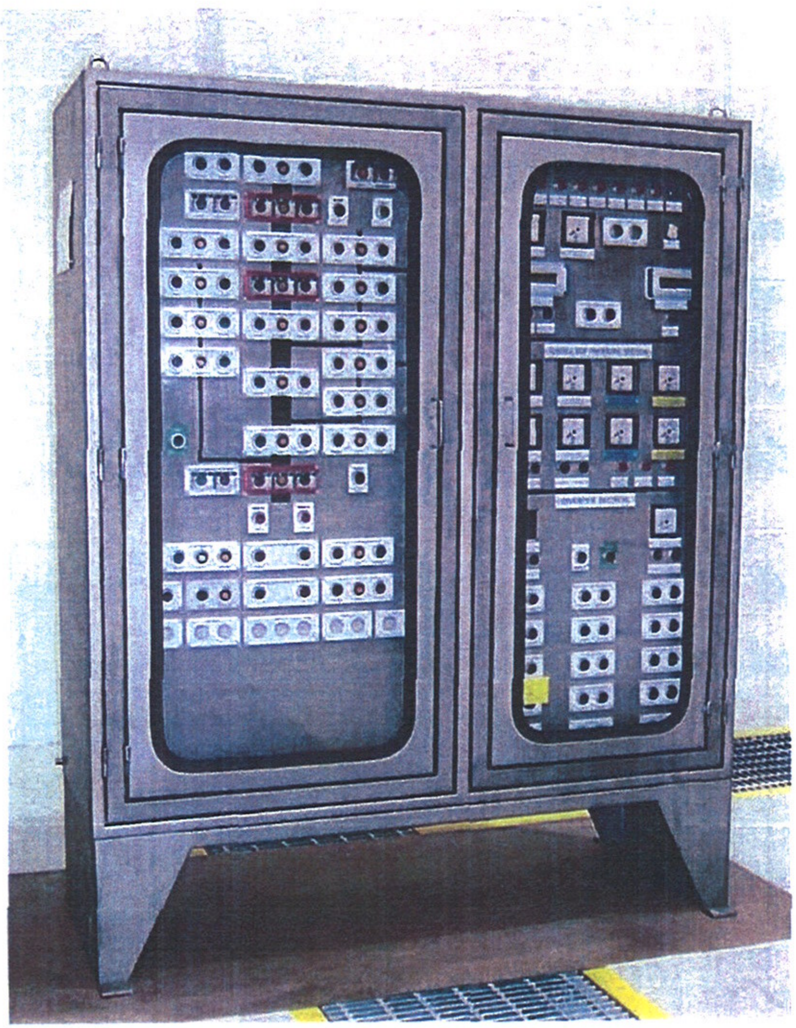
Seadrill 10 – West Hercules	Mark III Model 120
Seadrill 11 – West Aquarius	Mark III Model 120
Sevan Driller	Mark III Model 120
Schahin (2400M) – SS Amazon	Mark III Model 120
Schahin (2000M) - Casablanca	Mark III Model 120
Scarabeo 8	Mark III Model 120
Arctic 1 Upgrade	Hyd Mod Pod
Groupo R 1	Mark III Model 120
Groupo R 2	Mark III Model 120
TMT #1	Mark III Model 120
TMT #2	Mark III Model 120
TMT #3	Mark III Model 120
Odebrecht 1	Mark III Model 120
Odebrecht 2	Mark III Model 120
Songa Trym Upgrade	Hyd Mod Pod
Seadrill 14	Mark III Model 120
DrillMax 4 – Stena Ice	Mark III Model 80
Murphy Azurite ESG Project	ESG Acoustic
Pride Amethyst Mark III Upgrade	2 Mark III Model 80 MUX
Pride Amethyst Mark III Upgrade	2 Mark III Model 80 MUX
Pride Amethyst Mark III Upgrade	2 Mark III Model 80 MUX
Aban Abraham	Mark I

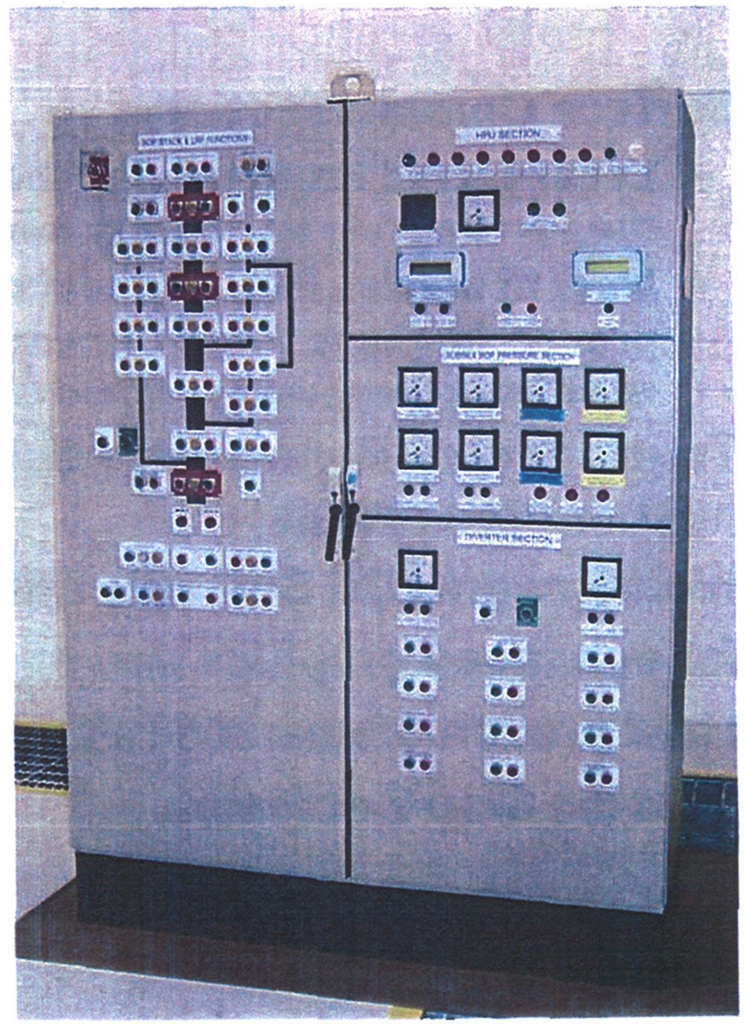
Surface Changes

- **Surface Communications**
  - **Legacy used Profibus via Fiber Optics with OLM's**
    (Star type network with poor diagnostic capabilities)
  - **Mark III utilizes Ethernet technology via Fiber Optics with field proven Siemens Fiber Converters/Switches**
    (robust network management for increased uptime with enhanced diagnostics)
- **Touch Screen Panels have been developed to replace hardwire push-button panels**
- **Wonderware HMI Software utilized for enhanced graphics and ease of use**
- **Field proven Siemens S7 PLC's utilizing Step 7 software**



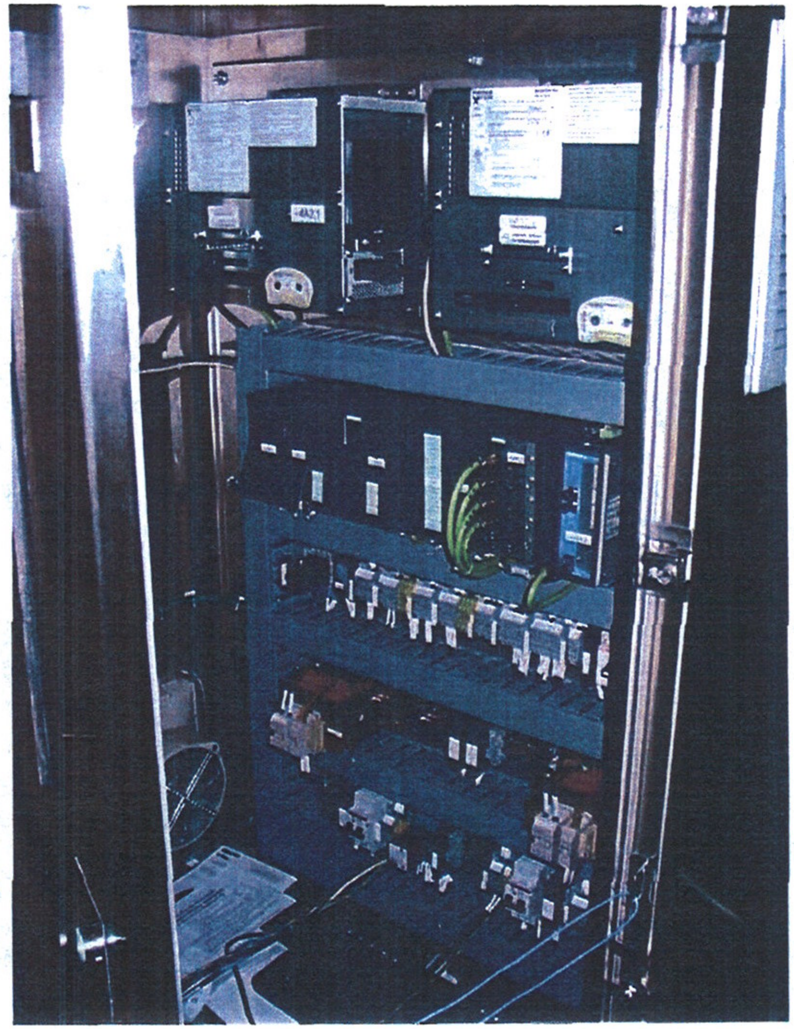
Legacy DCP & TCP





Touch Screen Panels

Touch Screen Panels



Subsea Changes

- Number of 1 atmosphere chambers reduced
- Power and signal go directly to SEM
- RCB has separate power and signal
- All interconnection cabling is Version 2 PBOF with testable connections and field repairability

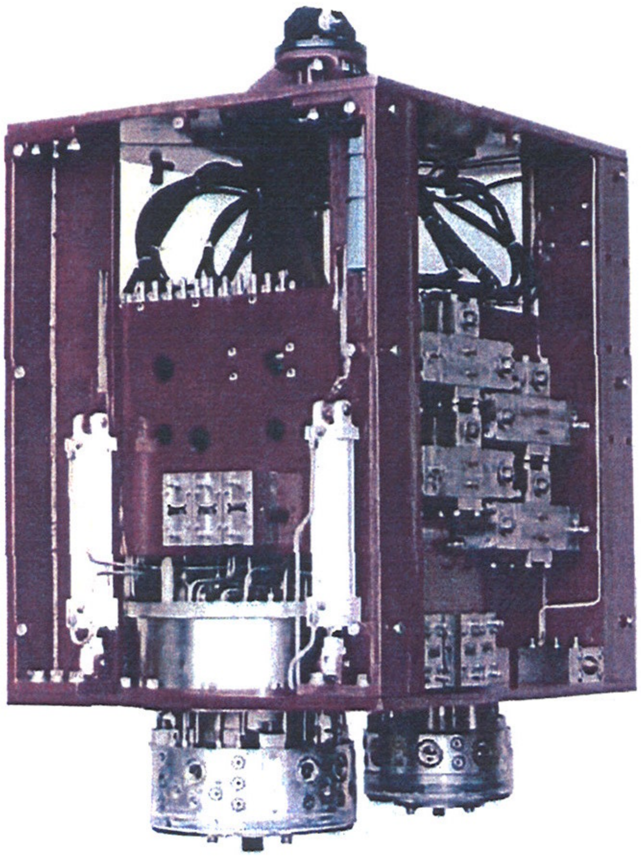
PODS

- Ben Ocean Lancer – 1st Gen MUX circa 1976
- Mark I – 2nd Gen 77 Functions circa 1995
  - Used Direct Hyd Mod Section developed in the late 70's
- Mark II – 2nd Gen Extended 107 functions circa 1998
  - Larger rectagular footprint

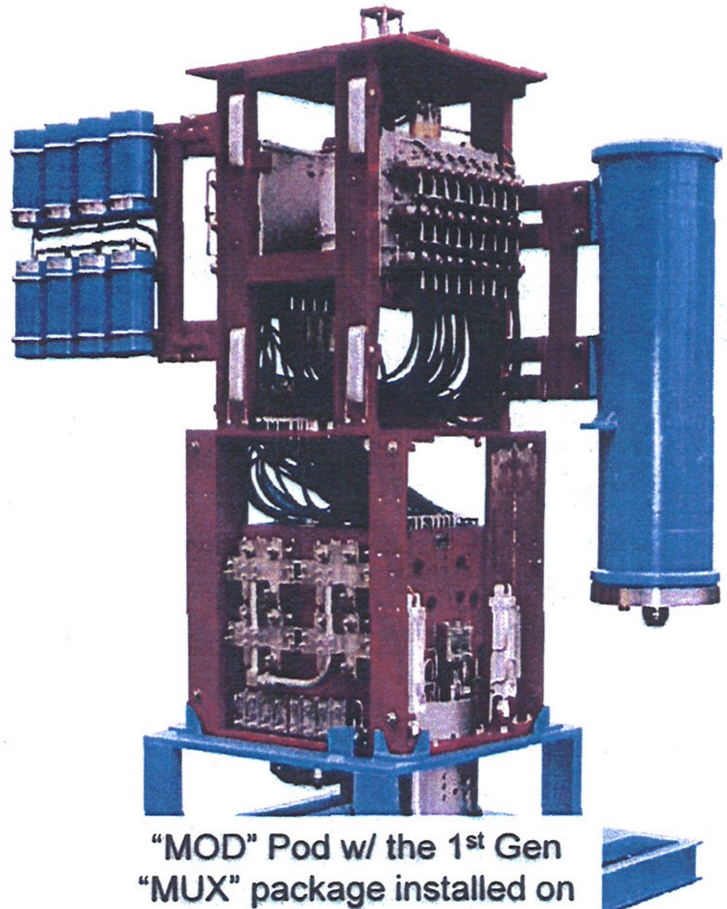
Current Generation (began development 2004)

- Mark III Model 80 (80 functions, base footprint)
- Mark III Model 120 (120 functions, rectagular footprint)

PODS

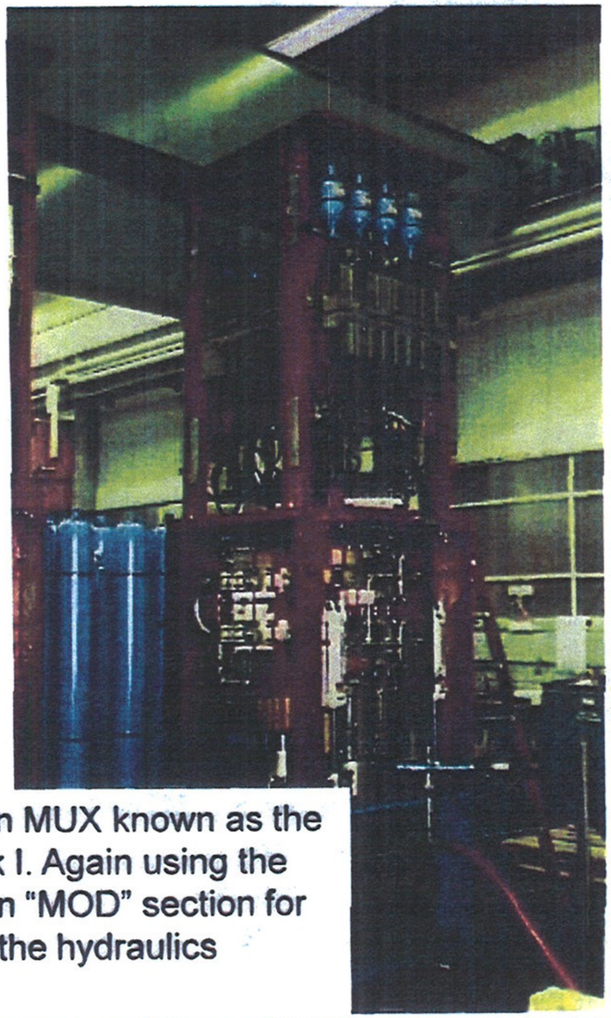


Original "MOD" Pod
Direct Hydraulic or Piloted
Circa 1970's

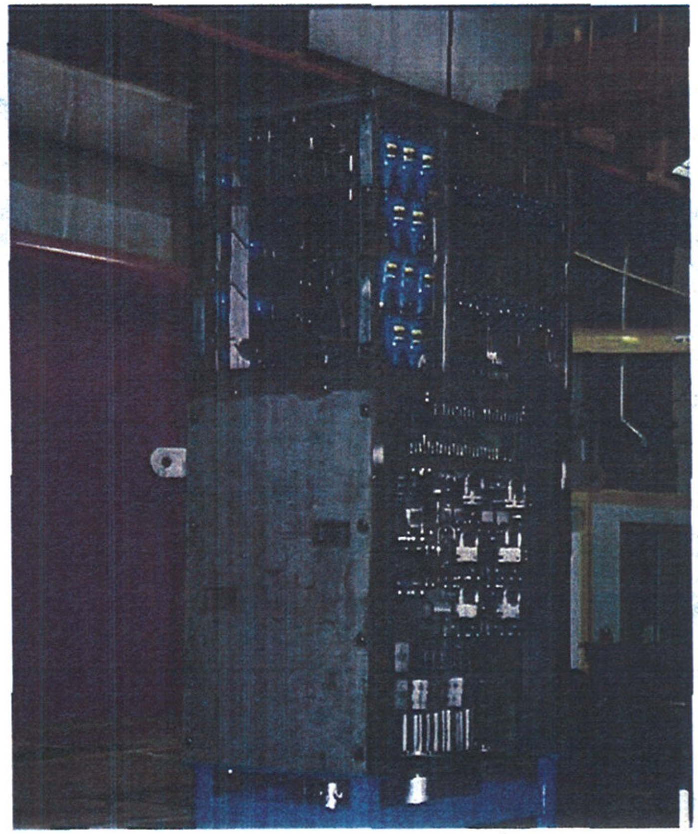


"MOD" Pod w/ the 1st Gen
"MUX" package installed on
the Ben Ocean Lancer.
Circa 1976 (today the vessel
is known as the SC Lancer

PODS

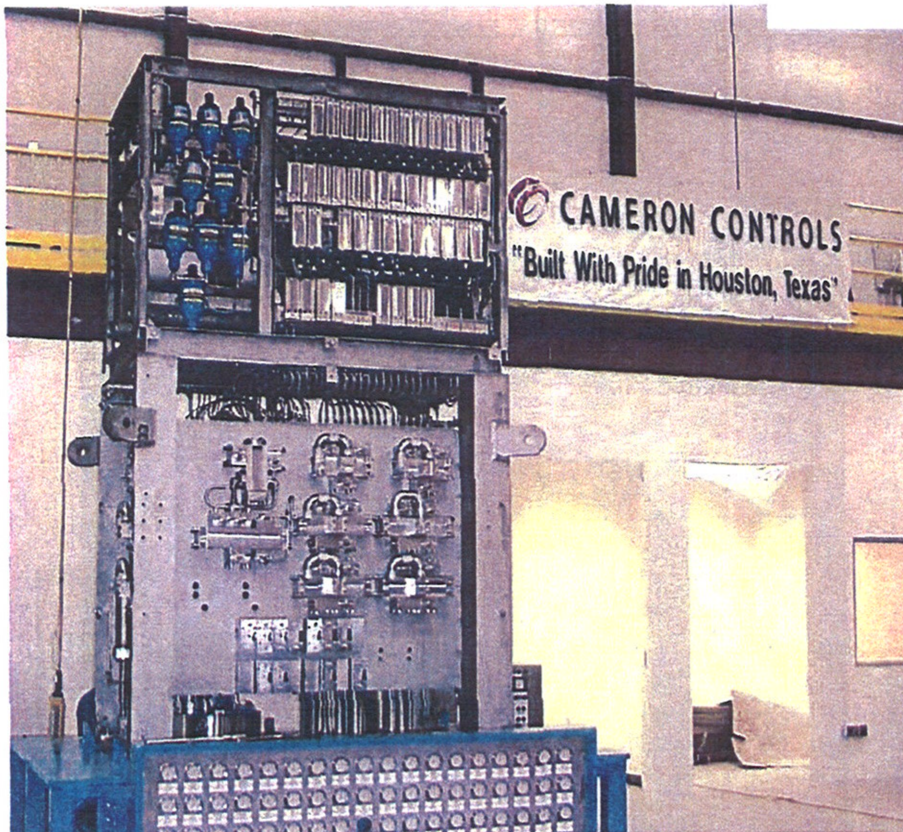


2nd Gen MUX known as the Mark I. Again using the proven "MOD" section for the hydraulics

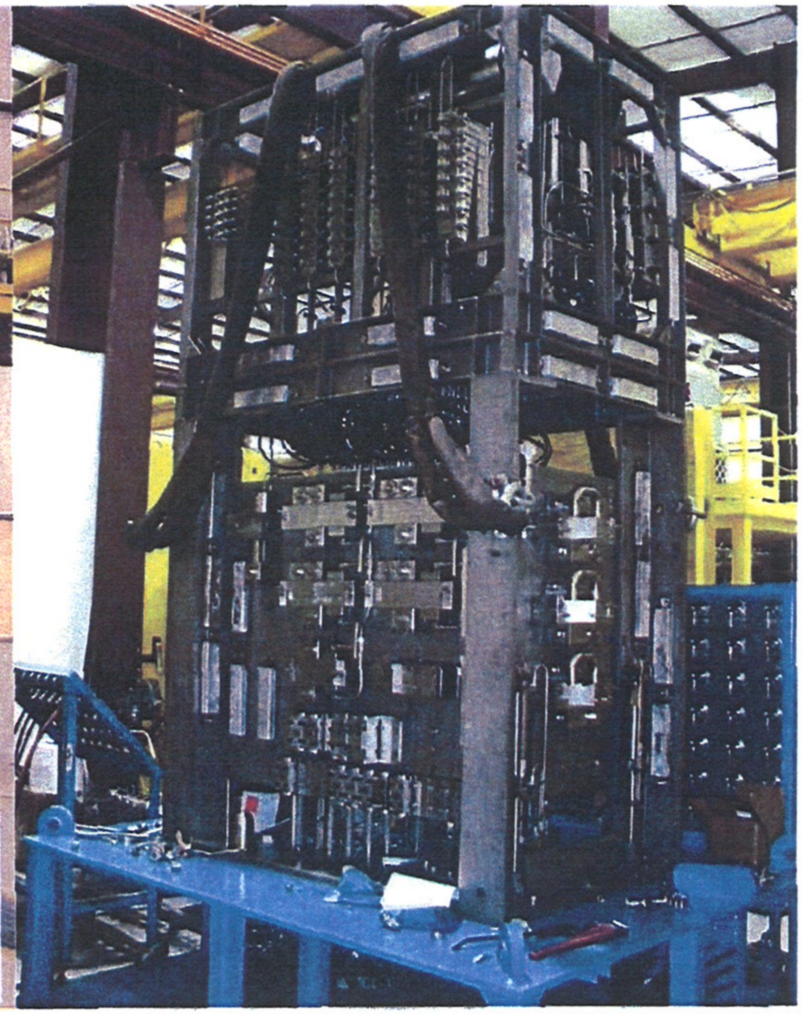


Mark II is a larger version of the Mark I for an increased number of functions.
1st St/Stl frames.

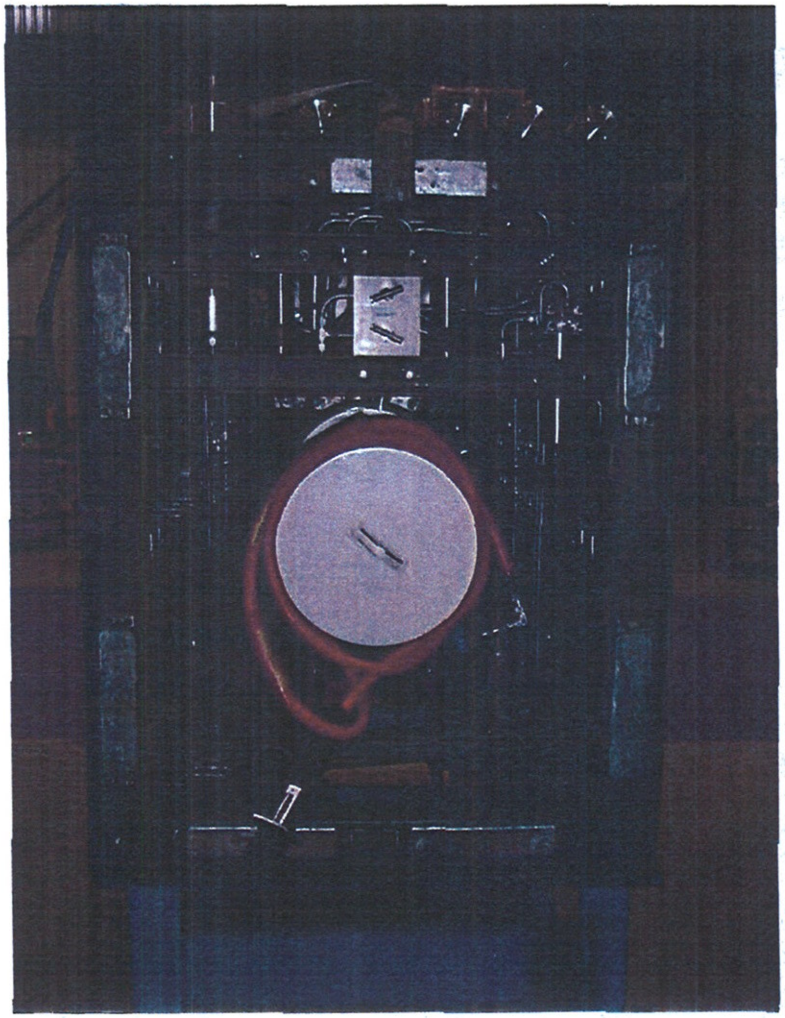
Mark III Model 80 & Model 120 (shown) were developed to incorporate lessons learned and enhance reliability.

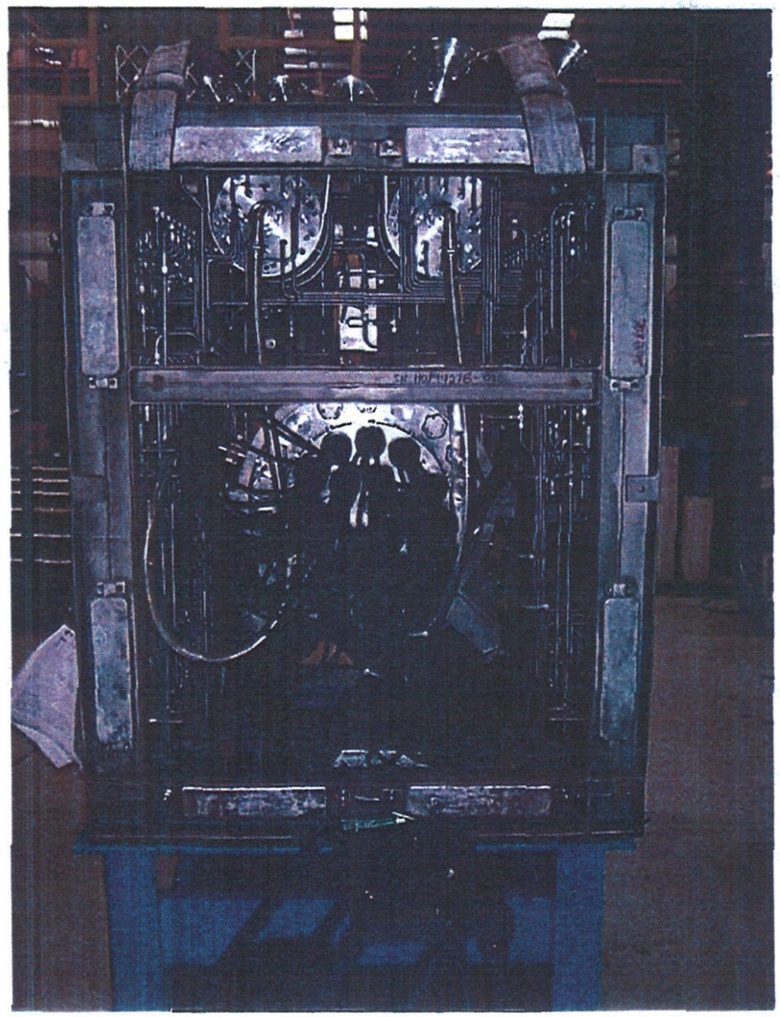


Mark II used the stack stinger from the Mark I as the Riser Stinger and a larger Stack Stinger was designed.

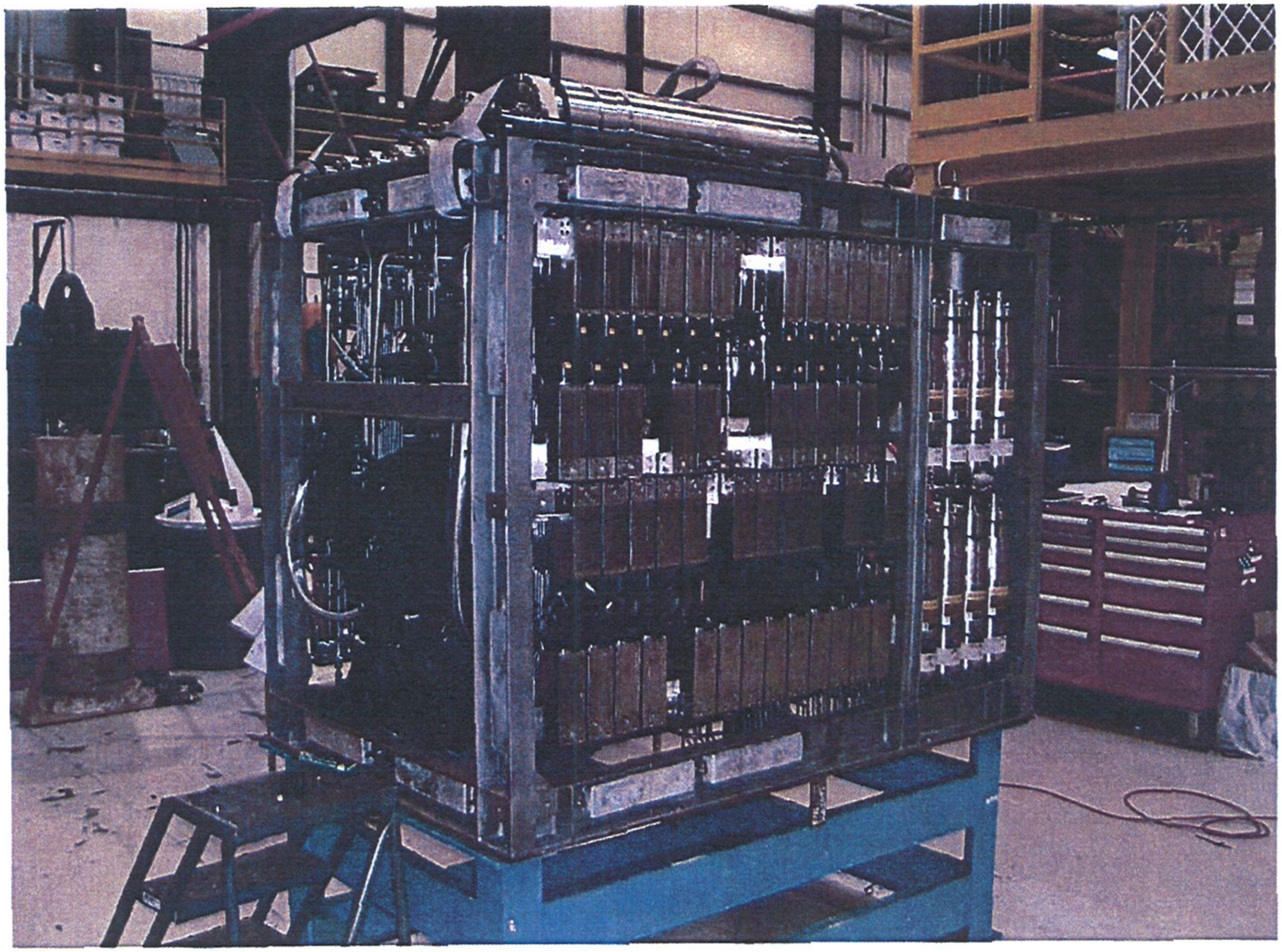


Mark II MUX Package

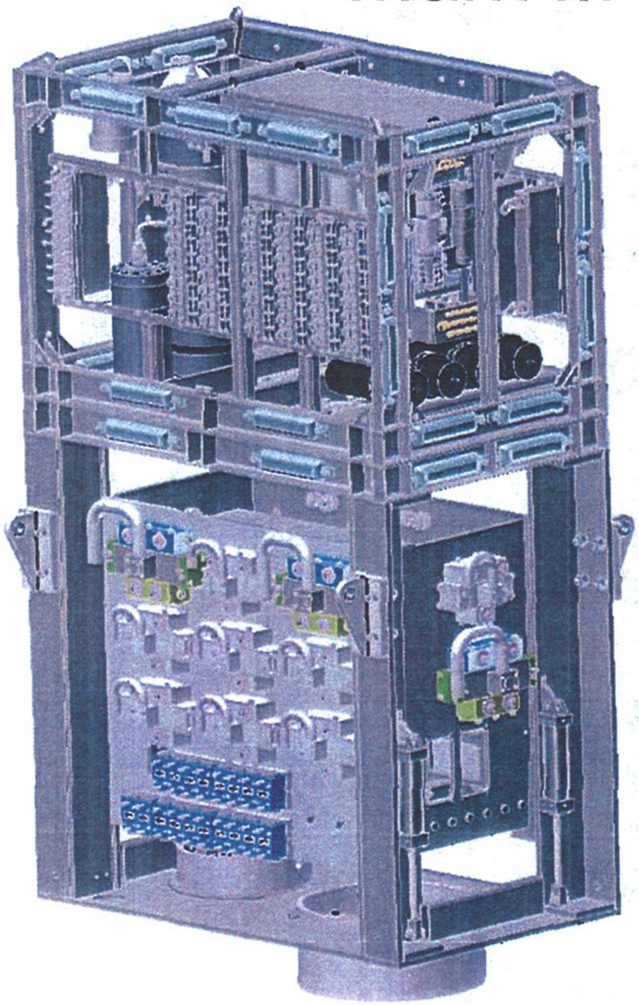


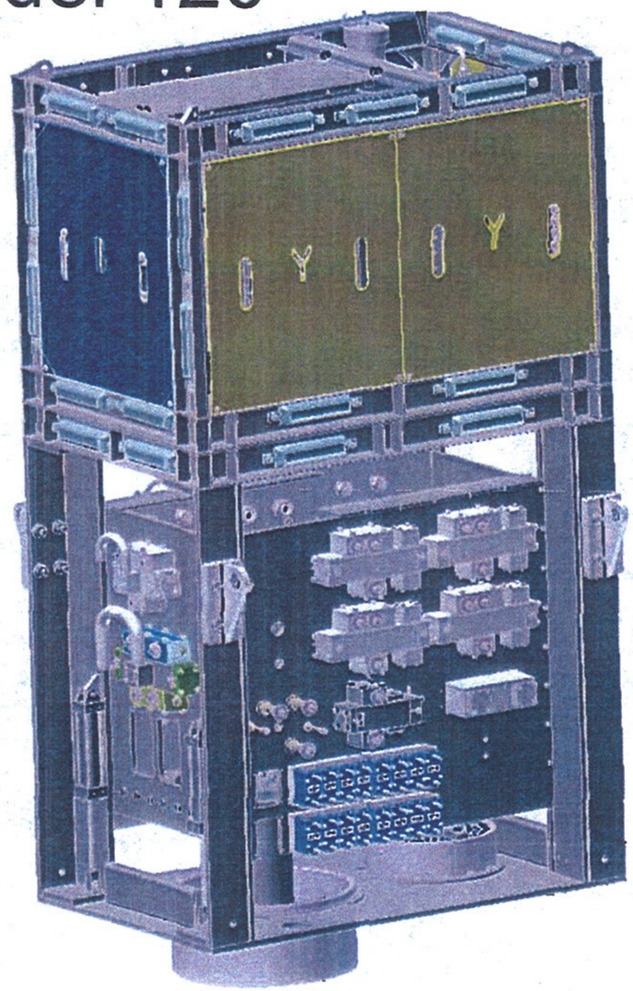


Mark II MUX Package



Mark III Model 120

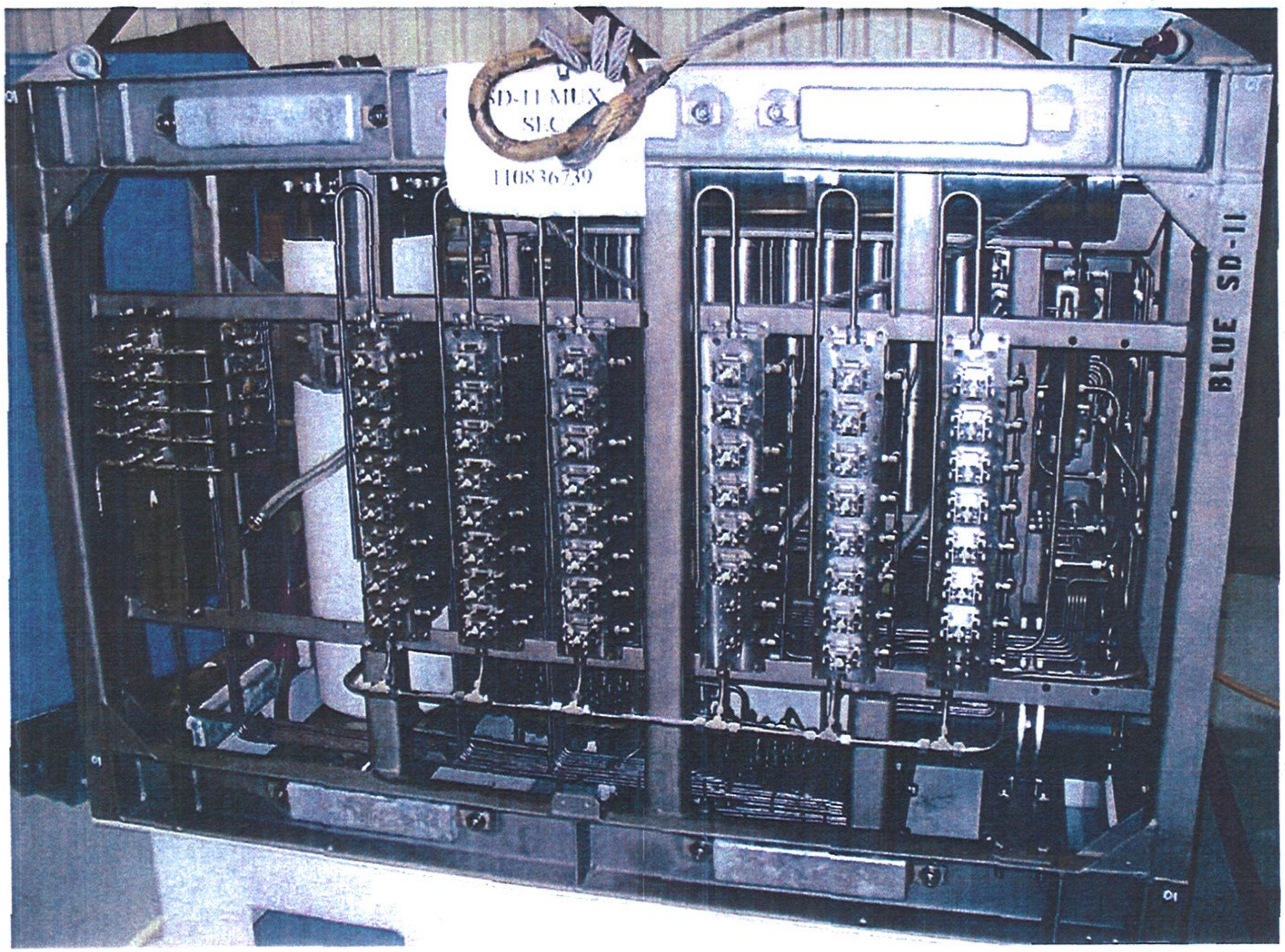




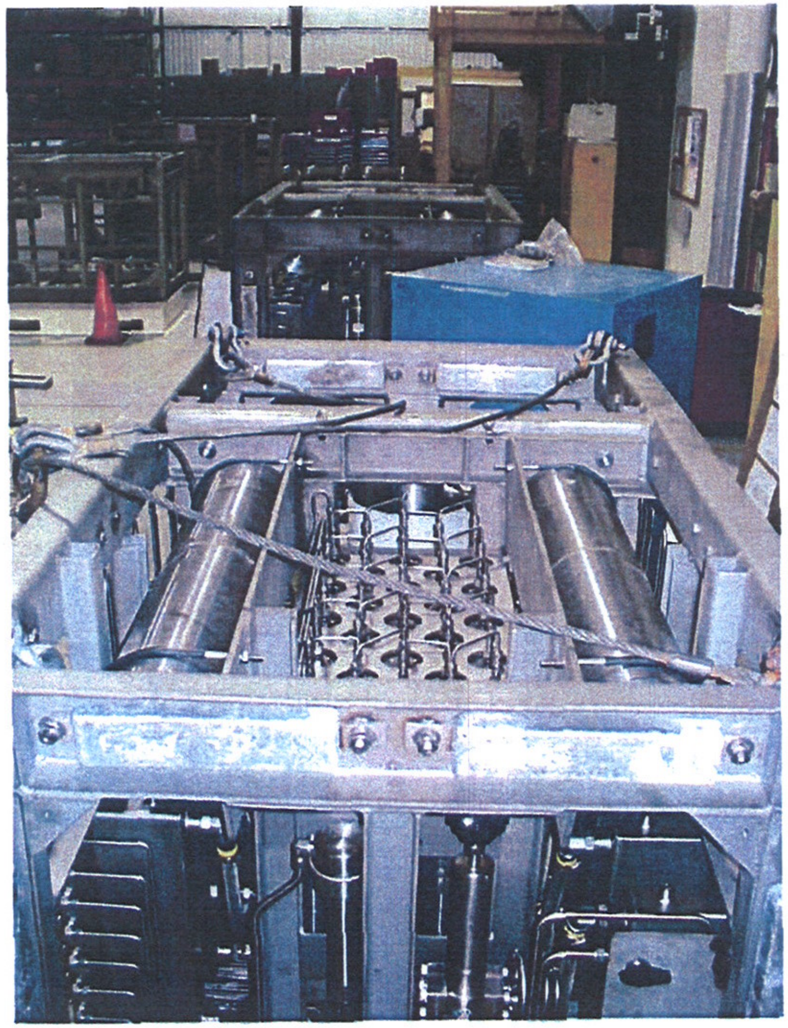
Mark III MUX Section

- Completely Repackaged for ease of maintenance
- Pressure compensated dielectric filled chambers
  - Solenoids
  - Transducers
- Modular construction
  - Solenoid chambers
  - Transducer chambers
  - Pilot Accumulator, Regulator & Filter rack
- Junction Plate for hydraulic interface between MUX / Mod
- New compact SEM design with next-gen electronics
- Rechargeable batteries for AMF/Deadman System

Mark III Model 120 MUX Section



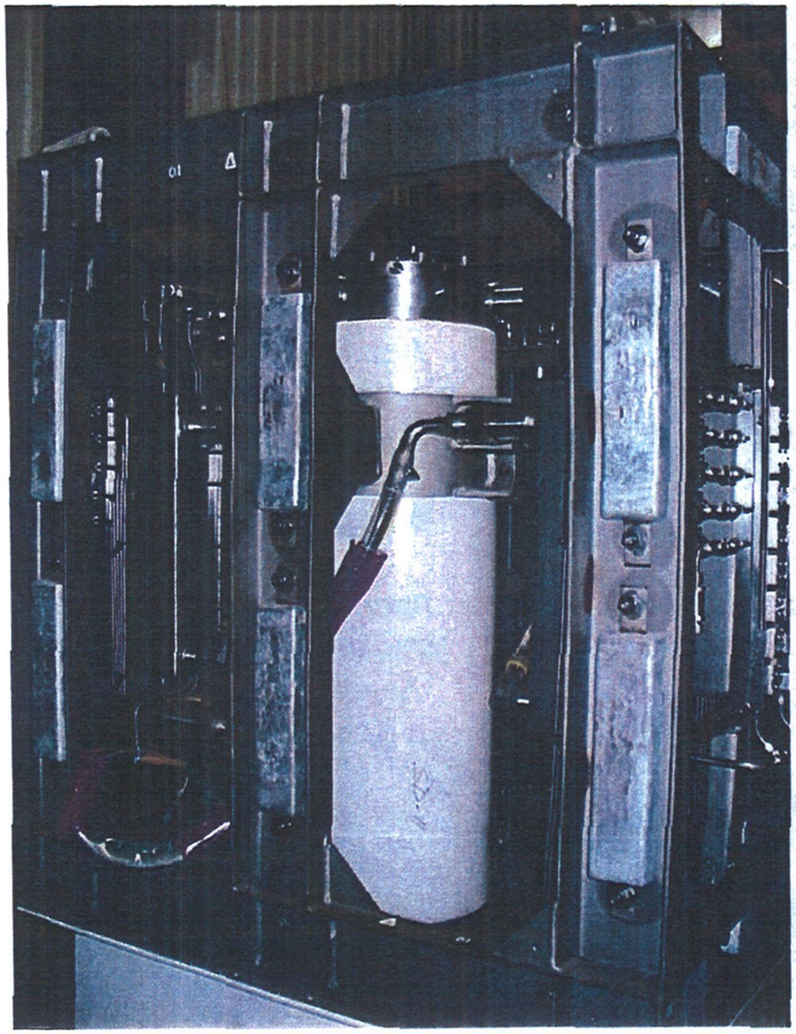
Mark III Model 120 MUX Section

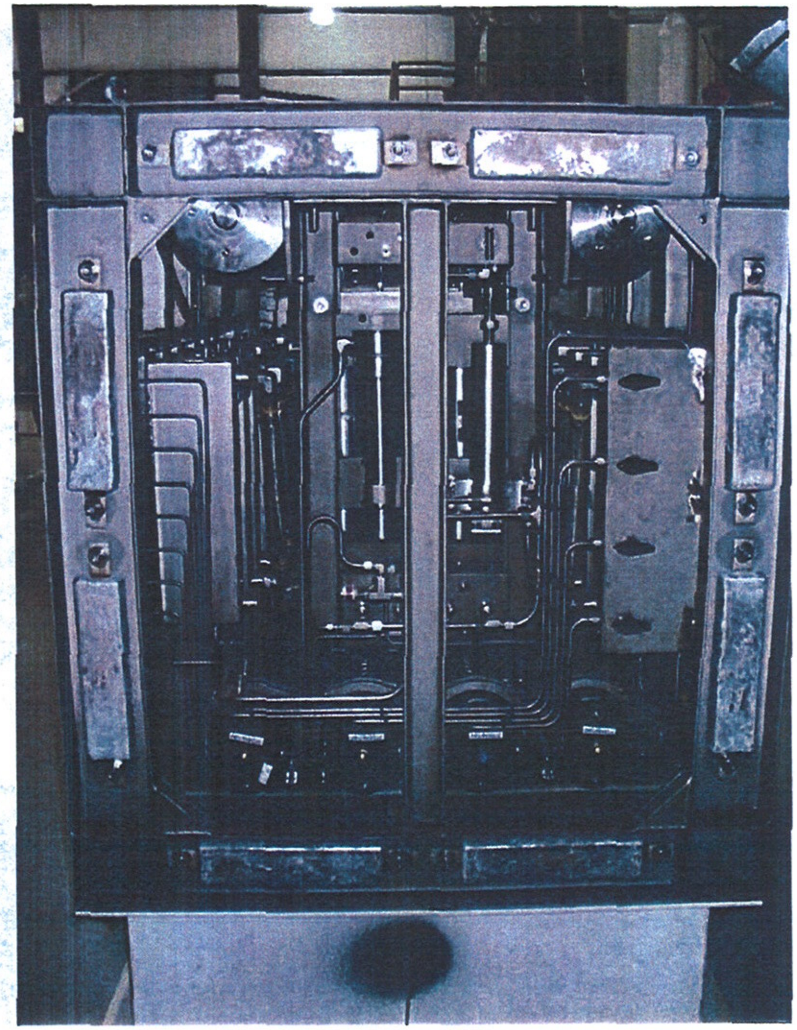


View showing "removable" St. Stl. Piston Pilot System Accumulator Module. (Lifts out from top of Mux Section)

Both the Main (larger) Pilot system Accumulators and the (smaller) Regulator Pilot Accumulators are all piston type.

Mark III Model 120 MUX Section

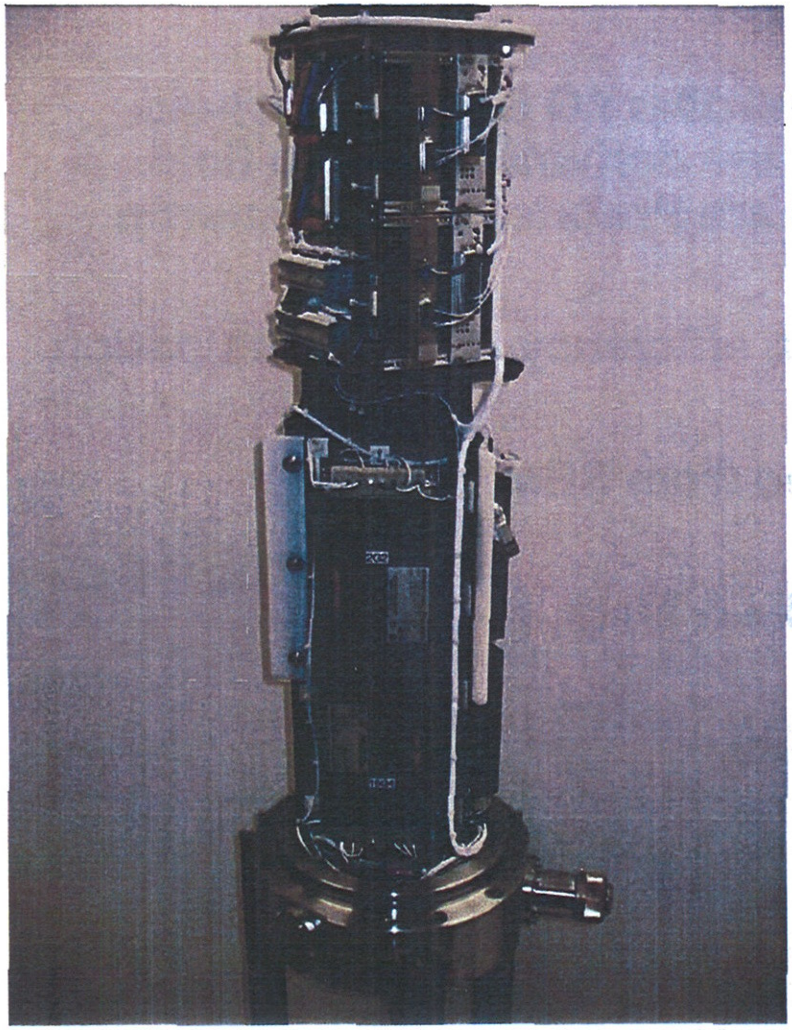


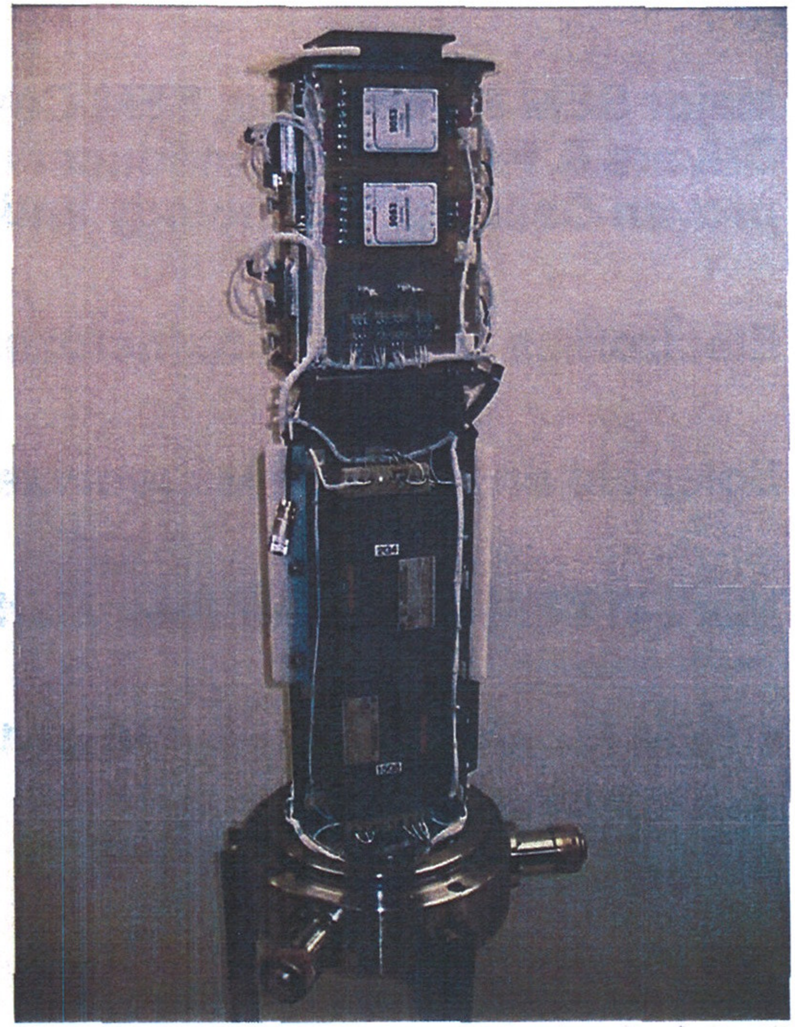


Mark III SEM Features

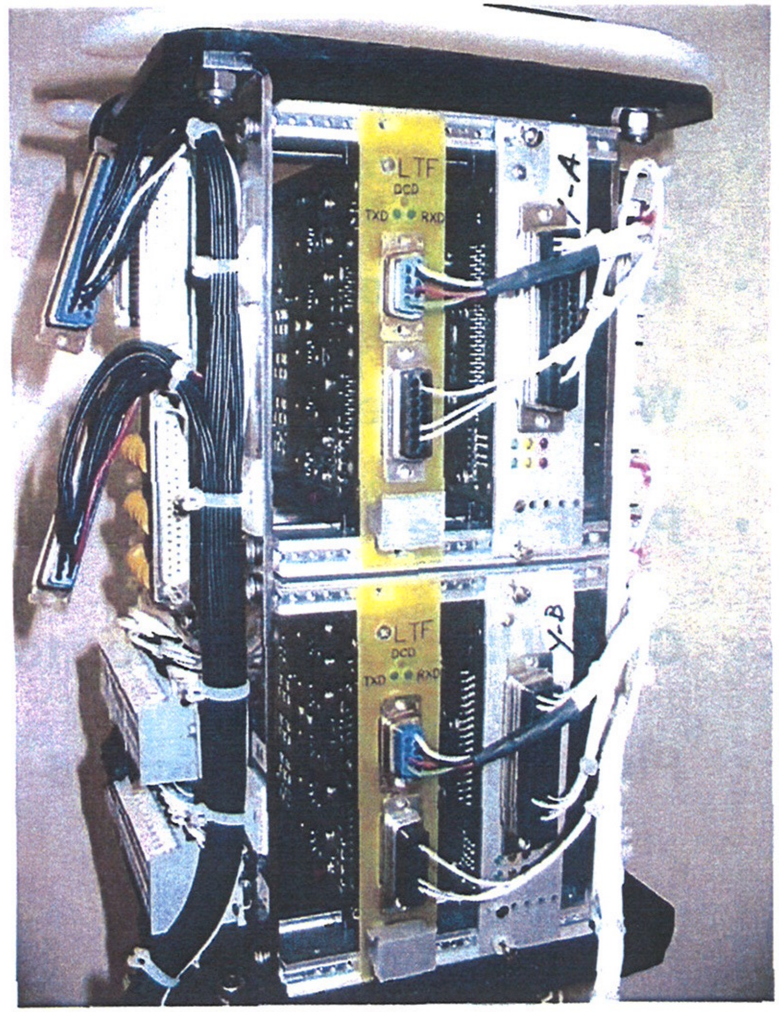
- Major SEM Electronics, SEM Controller I\O Board, Solenoid Drivers & Pressure Transducers are derivatives of the field proven CamTrol technology and are Proprietary to Cameron
- Electronics packaged to increase efficiency of heat dissipation
- Solenoid driver modules removed from SEM
- Mark III SEM is smaller than Mark I & Mark II
- 1 SEM for both the Model 80 or 120
- Pie connectors eliminated

Mark III SEM (Subsea Electronics Module)





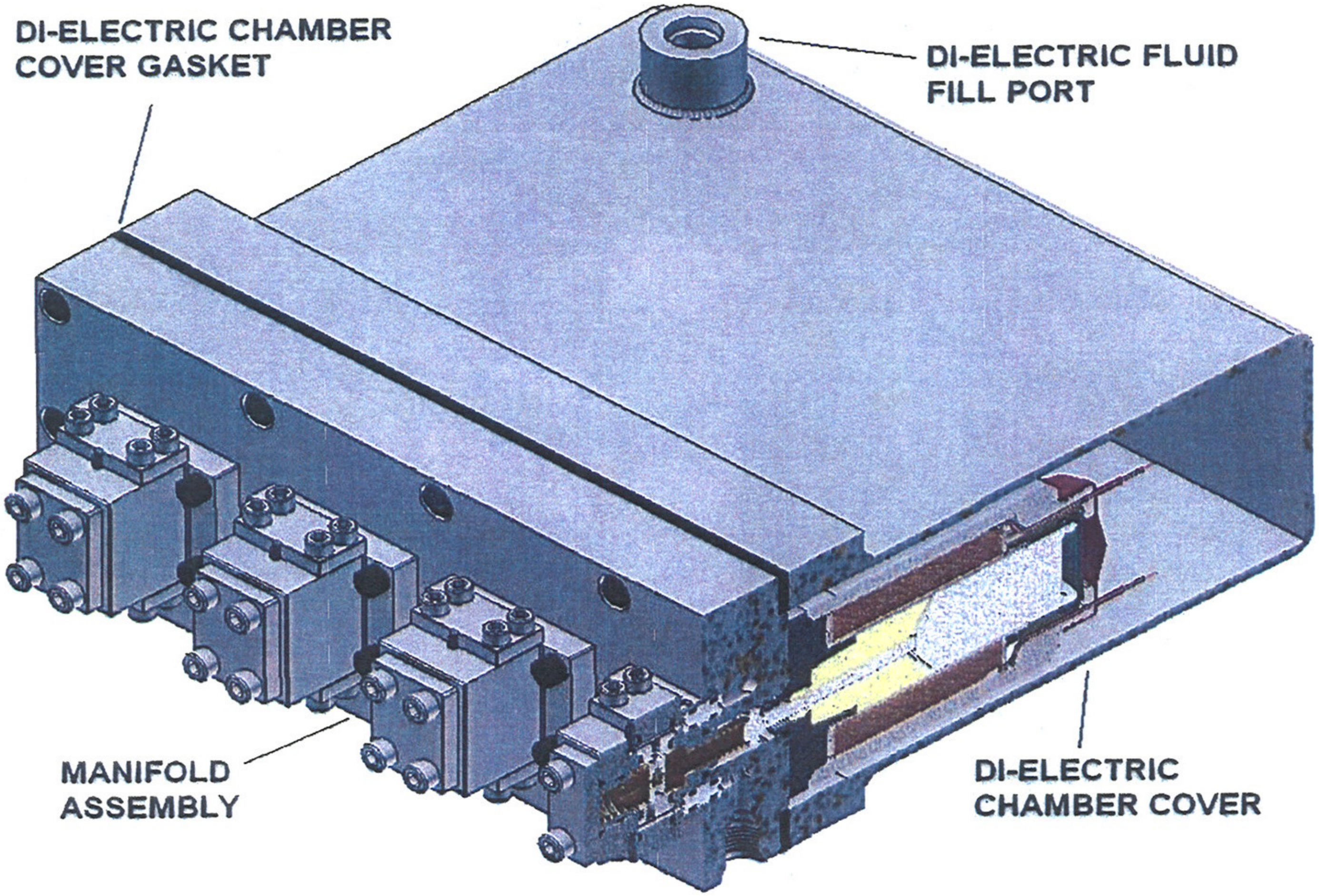
Mark III SEM (Subsea Electronics Module)



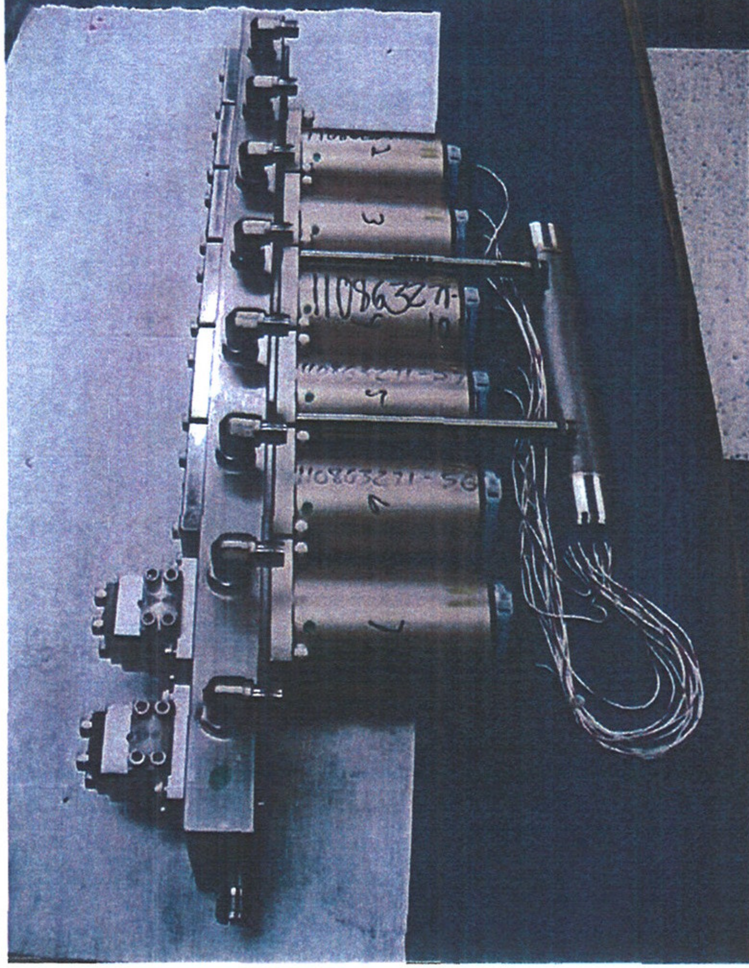
SVM (Solenoid Valve Module)

- SDM (Solenoid Driver Module) included in each SVM
- Module is dielectrically compensated
- Wires between SDM and coils are booted
- PBOF hose for SVM interconnect
- CANBUS communication to SEM
- Pie Connectors eliminated

Solenoid Valve Module



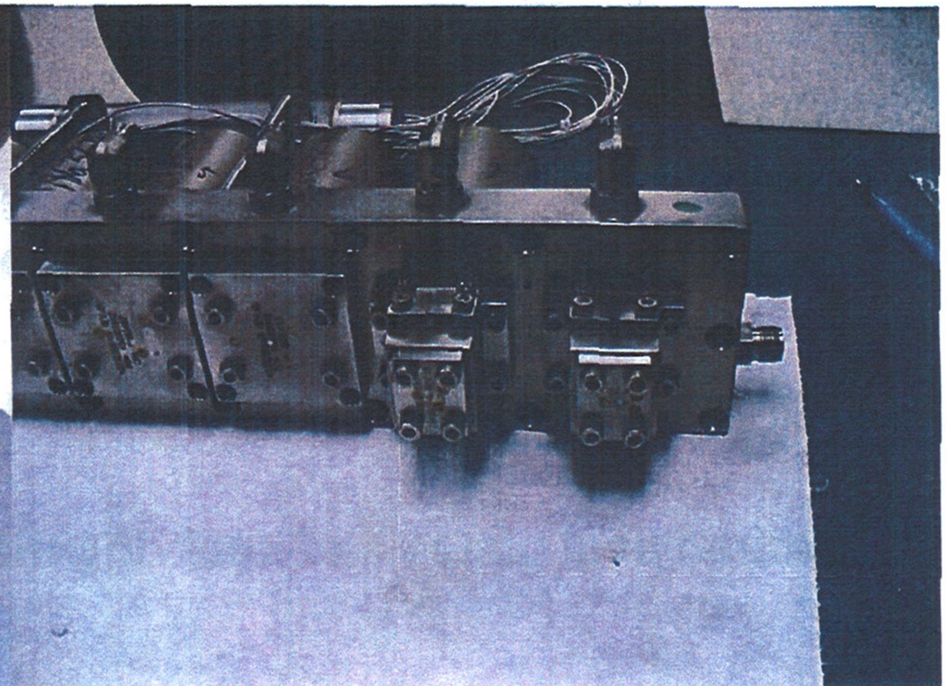
Solenoid Valve Module



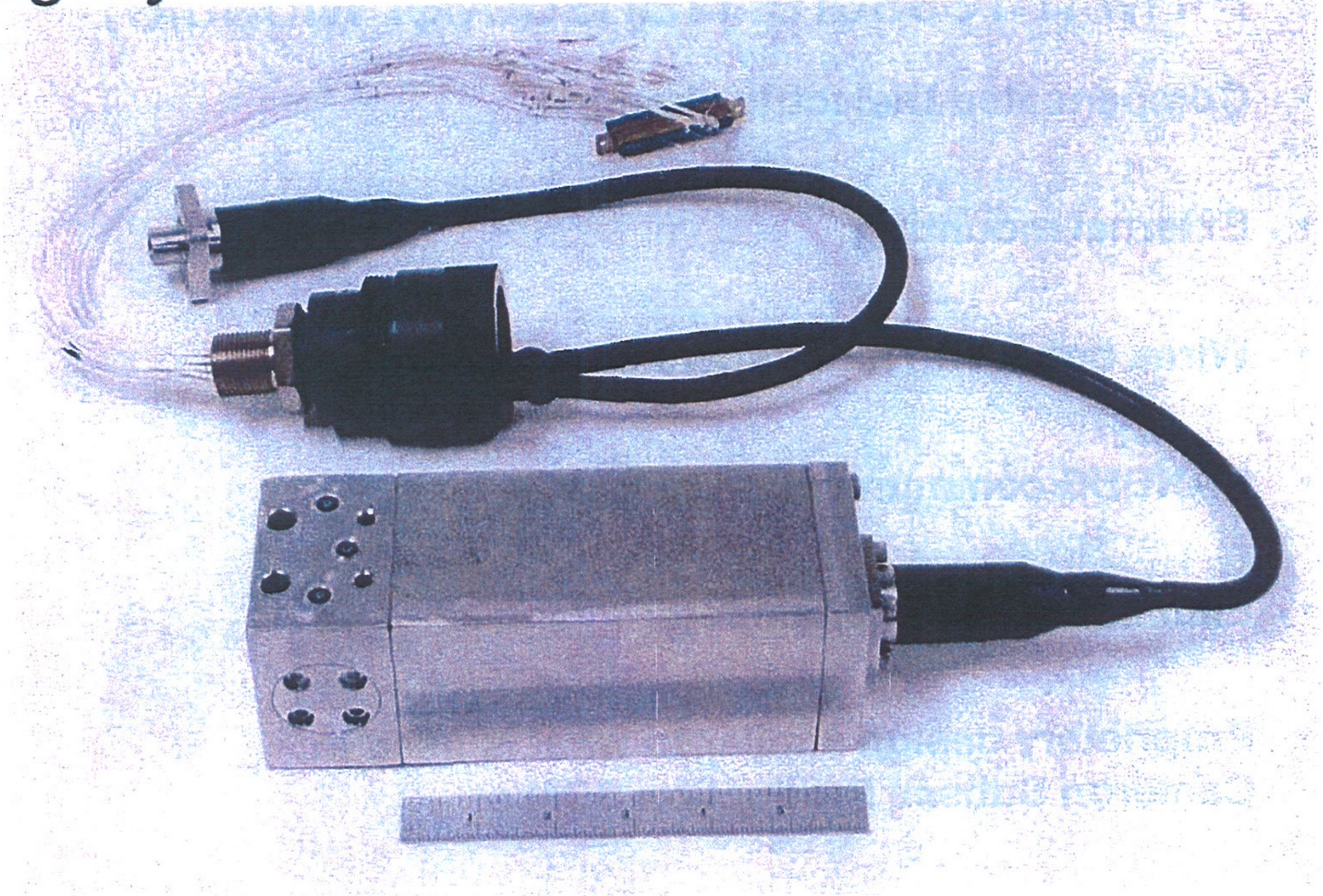
Solenoid Valve Features

- **Hydraulic section is divorce mounted for ease of maintenance**
- **Coil section is compensated with dielectric**
- **Single coil design with higher pull-in force**
- **Premium seal plates and seal ring materials**

Solenoid Valve Assembly



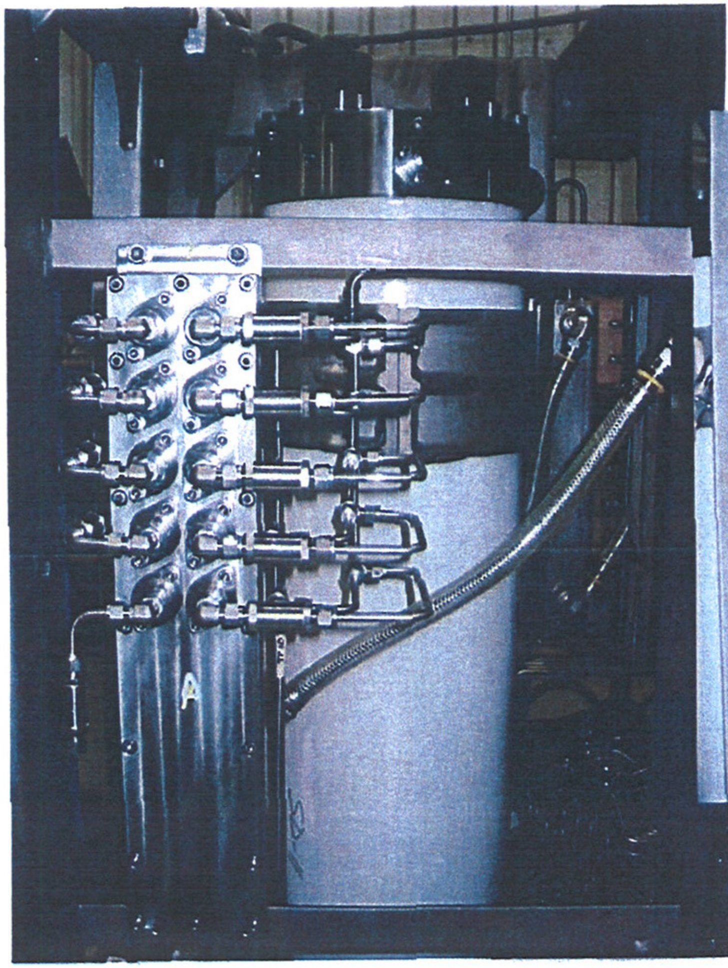
Legacy -63 Solenoid Valve & Pie Connector

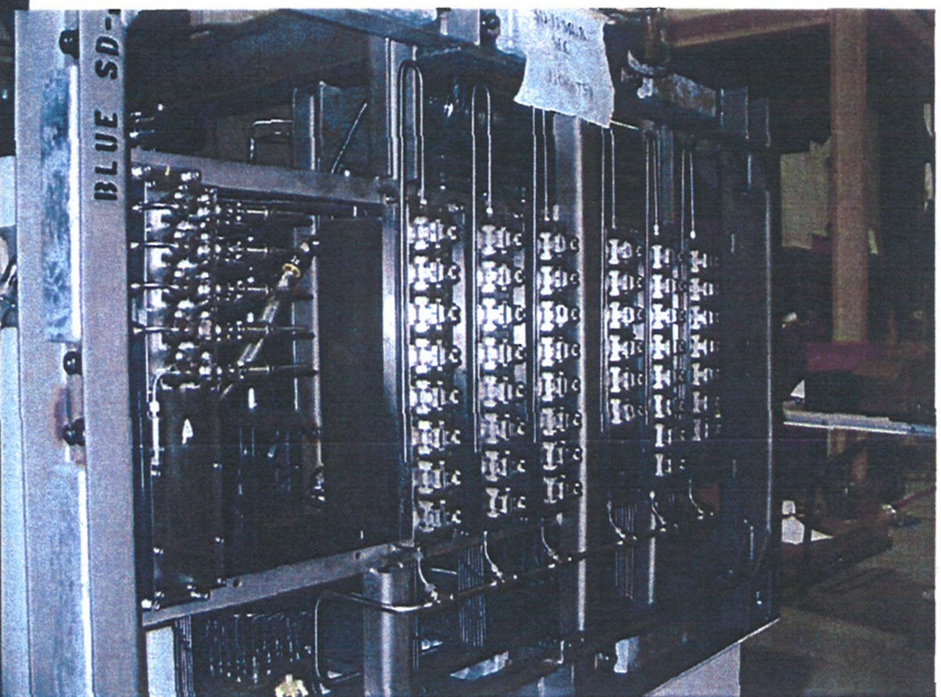


PTM (Pressure Transducer Module)

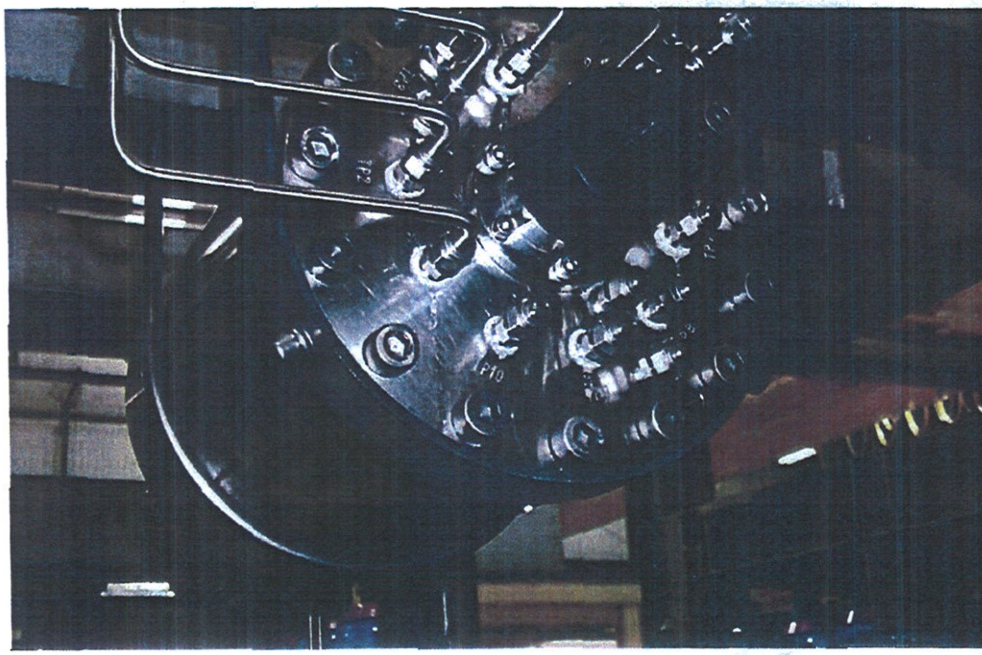
- **Compensated Dielectric chamber**
- **External mounting**
- **Wires between Transducers are booted**
- **CANBUS communication to SEM**
- **Eliminates 1 ATM chambers**
- **Proprietary design similar to what is used in Cameron Subsea Production SCM's**

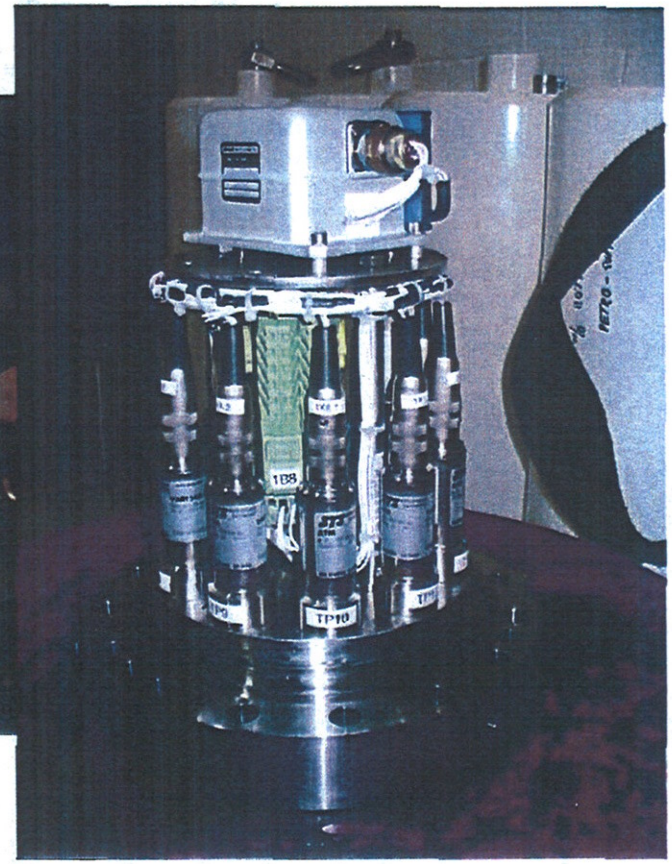
Pressure Transducer Module



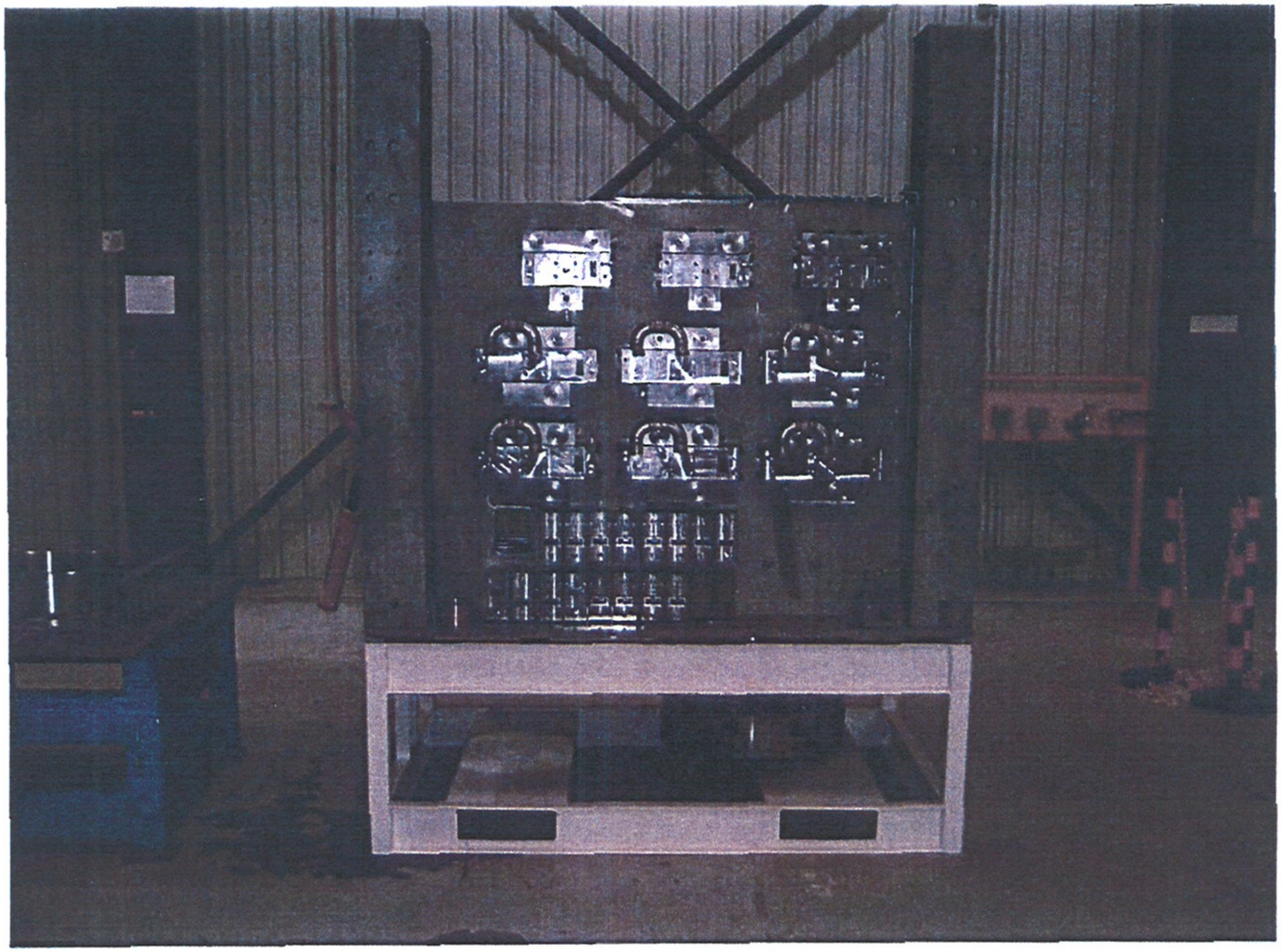


Legacy Pressure Transducer Module





Mod Section



Mark III MOD Features

- **Premium Deepwater Valve and Regulator series**
  - ✓ **1-½" and ¾" Regulators**
  - ✓ **1-½", 1", ¾", ½", and ¼" Valves**
- **Field Proven Pressure Balanced Retractable Stingers**

CAMERON

the Industry Leader in
MUX Control Systems

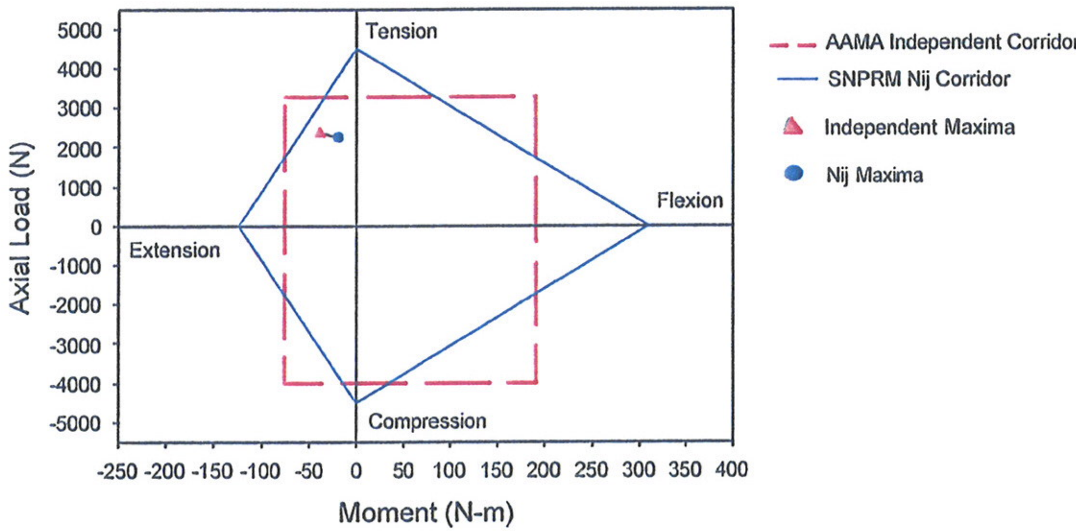


Figure 3-7. Typical Plot Comparing Nij with Current Injury Criteria.

The point corresponding to the Nij criteria, labeled with a •, is located at the values of axial load (F_Z) and flexion/extension bending moment (M_Y) which yield the maximum value for Nij. It is important to realize that these values for F_Z and M_Y are concurrent in time and are not necessarily equal to the maxima during the entire event. The point corresponding to the AAMA proposed values for out-of-position, labeled with a •, is located at the overall maximum values of axial load and bending moment. The two values that determine this point are independent of time, and do not necessarily occur at the same time. It is also important to notice that shear load is not included on this plot.

Since the AAMA independent point always represents the overall maxima while the Nij point does not, it is impossible for the Nij point to be located further from the origin than the 208 point. To help identify the matched sets of points, they have been joined together by a line. If the line segment is short, and the points lie essentially on top of one another, it implies that the Nij maximum value occurs close to the same time as the independent maxima. If the line segment is long, this indicates that the Nij maximum occurs at a much different time than the independent maxima.

The thick broken rectangle in Figure 3-3 represents the AAMA proposal for neck injury criteria for axial load and bending moment in out-of-position testing. The AAMA's suggested independent limits for tension, compression, flexion and extension which are the same as those used currently for the 50th percentile male in the alternative sled test option, with the exception of the extension value. The AAMA's proposed a limit in extension for the 50th percentile male is 77 N-m for out-of-position testing and 96 N-m for in-position testing, which are higher than the 57 N-m used currently for the sled test. The AAMA reasoned that for in-position testing because the occupant would be aware of the crash and would tense the neck muscles, the performance limits could be raised for tension and extension.

However, the agency has determined that it is not prudent to raise these limits because not all occupants, especially passengers, may be aware of an impending crash and furthermore because there was little scientific data to support the large increase in the extension tolerance to 96 N-m. Thus, the limit of 77 N-m is plotted for the extension limit for the 50th percentile male. The solid "kite" shape represents the Nij = 1.0 criteria, corresponding to a 22% risk of an AIS• 3 injury. The vertices for each region shown on the plot are scaled for each different dummy size. Data points lying within either the box or kite are considered to pass the corresponding criteria.

3.5.1 Vehicle Crash Testing with the 50th Percentile Male Dummy

NCAP data from 1996 through1999 were analyzed for both drivers and passengers. A total of 307 occupants from 154 tests conducted from 1996 to 1999 were analyzed. Results are summarized in Figures 3-8 and 3-9 and also in Appendix Figures C.1 through C.4. In each year, more than 90% of the occupants in the driver or passenger position passed SNPRM Nij performance limit of 1.0, with a maximum value 1.42 for the driver in a model year 1996 vehicle with an airbag and a maximum value of 1.55 for one passenger in a model year 1996 vehicle with an airbag.

Limited crash test data are available for the analysis of neck injury risk in unbelted frontal collisions because neck load cells were not required in compliance tests prior to the 1997 adoption of criteria in the sled test alternative under FMVSS 208. A series of thirteen tests conducted under FMVSS 208 barrier crash conditions with 1998 and 1999 vehicles was conducted by the agency using the 50th percentile male dummy. Results from these tests are shown in Figure 3-9 and in Appendix Figures C.5 and C.6. All thirteen tests, both drivers and passengers, easily fall within the allowable range for the SNPRM Nij criteria.

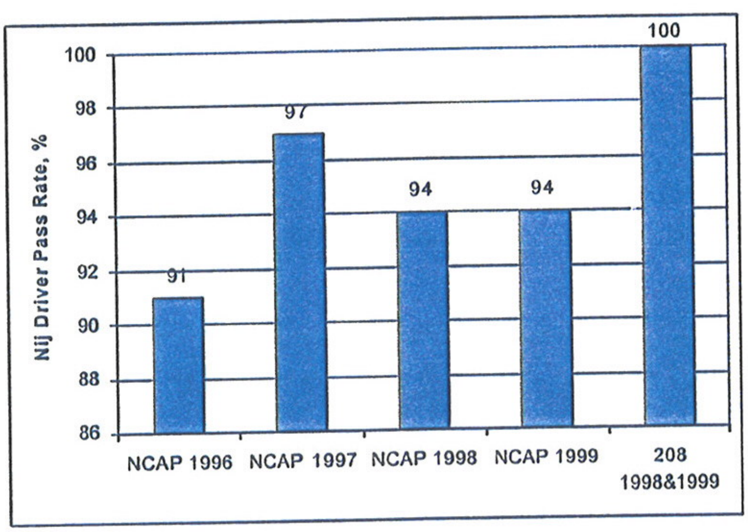


Figure 3-8: SNPRM Nij Pass Rates for the 50th percentile male dummy in the driver position Belted NCAP at 35 mph into flat, rigid barrier, and unbelted 208 tests at 30 mph into flat, rigid barrier.

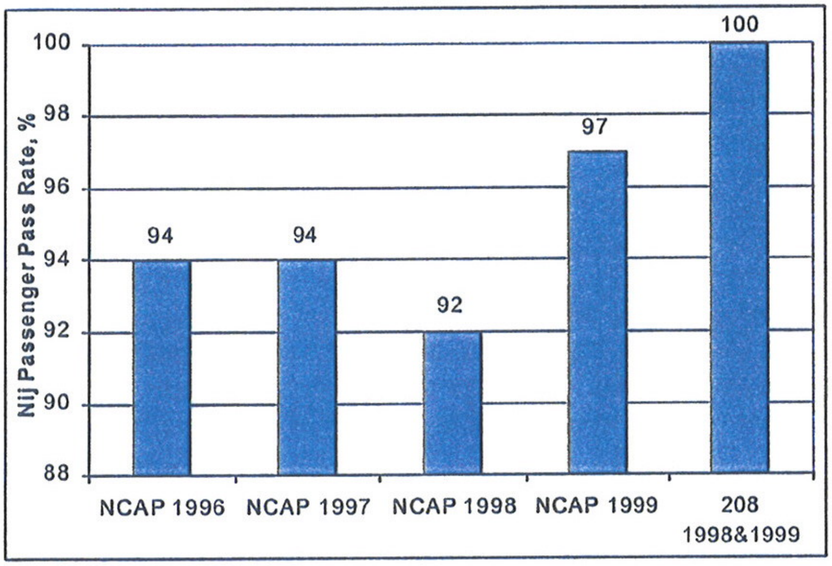


Figure 3-9: SNPRM Nij Pass Rates for the 50th percentile male dummy in the passenger position Belted NCAP at 35 mph into flat, rigid barrier, and unbelted 208 tests at 30 mph into flat, rigid barrier.

3.5.2 Vehicle Crash Testing with the 5th Percentile Female Dummy

Data from recent tests conducted at Transport Canada using belted Hybrid III 5th percentile female dummy in model year 1998 and 1999 vehicles were also analyzed. In these tests, the 5th percentile female dummies were belted with the seat positioned as far forward as possible and the seatback adjusted slightly more upright. Due to the far forward seating position and potential for late deployments for the offset tests, these conditions are quite severe and are somewhat similar to dynamic out-of-position tests.

Results from 48 kph (30 mph) rigid barrier tests and low speed tests into an offset deformable barrier are presented in Figures 3-10and 3-11and in Appendix Figures C.7 thru C.10. For the twenty-six rigid barrier tests which were conducted, 65% of the drivers and 92% of the passengers passed the Nij performance limit of 1.0. For the twenty-nine 40 percent offset frontal tests conducted at speeds varying from 20 to 25 mph in which the air bag deployed, 66% of drivers and 90% of passengers passed the Nij = 1.0 criteria. In some of the lower speed offset tests, the air bag did not deploy and are indicated in Appendix Tables B.15 and B.16 with an asterisk.

These results using current air bag system demonstrate that testing with the belted 5th percentile female in the full forward position at speeds up to 30 mph in a rigid barrier or up to 25 mph into an offset deformable barrier is a practicable test which is being met by over 50% of the vehicles. Similar testing of the unbelted 5th percentile female dummy in a 30 mph rigid barrier test showed similar performance with 3 out of 4 vehicles passing on the driver and passenger side (Appendix Figures C.11 and C.12). However, this testing indicates that some vehicles will need to be redesigned to ensure safety for all occupant sizes at all available seating positions in the vehicles.

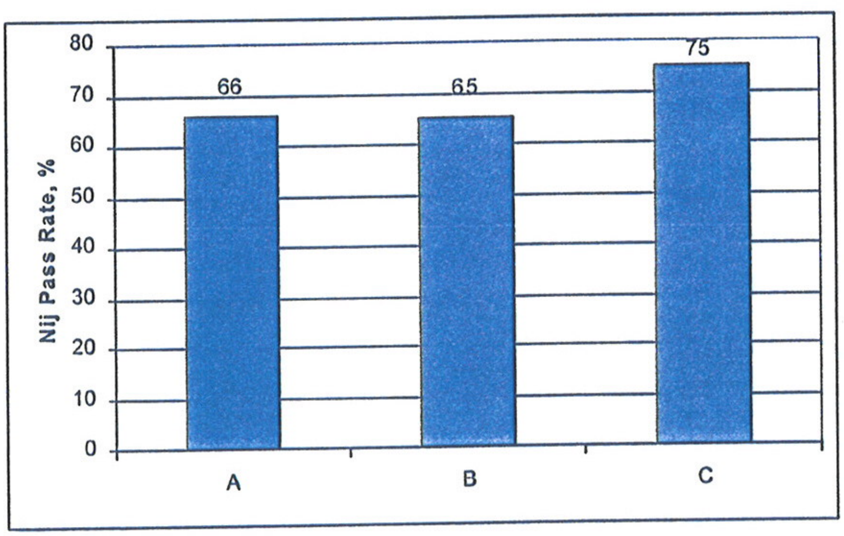


Figure 3-10:Nij Pass Rates for the 5th percentile female dummy in the driver position
A - belted tests at 25 mph into an offset deformable barrier, B - belted tests at 30 mph into flat, rigid barrier, and C - unbelted 208 tests at 30 mph into flat, rigid barrier

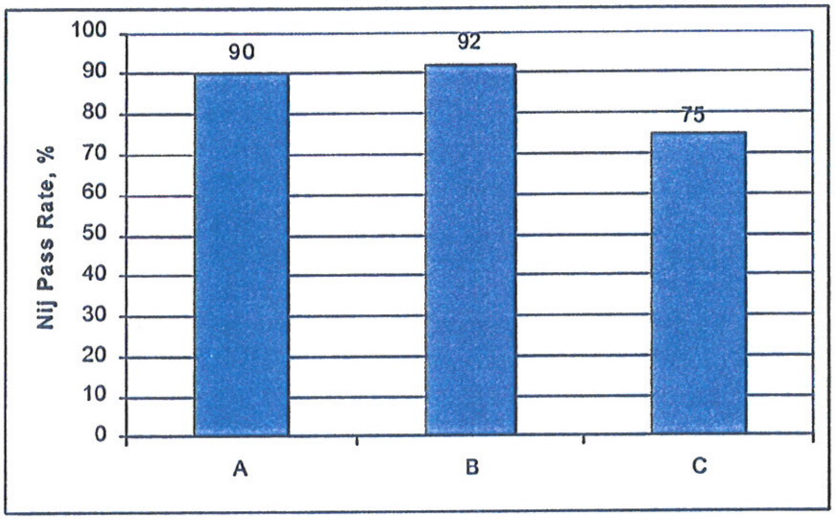


Figure 3-11 Nij Pass Rates for the 5th percentile female dummy in the passenger position
A - belted tests at 25 mph into an offset deformable barrier, B - belted tests at 30 mph into flat, rigid barrier, and C - unbelted 208 tests at 30 mph into flat, rigid barrier

3.5.3 Out-of-position Testing with the 5th Percentile Female Dummy and Child Dummies

Out-of-position tests for different sized dummies were also conducted and analyzed by NHTSA. Driver position 1 for adult dummies places the chin just above the airbag module; position 2 centers the sternum on the module. Driver position 1 tests for adults are intended to maximize loading to the head and neck, resulting in higher risk of neck injuries. For children, the position 2 places the chin above the airbag module. Thus, position 2 tests for children are intended to maximize loading to the head and neck, resulting in higher risk of neck injuries. Since these tests represent the worst case scenarios involving airbag deployments, dummy measurements are expected to be relatively high.

Results from the 5th percentile female tests using 1996, 1998 and 1999 model year air bag systems are shown in Figure 3-12 and in Appendix Figures C.13 and C.14. For the 5th percentile female dummy, 5 of 15 tests (33%) in position 1 and 10 of 15 tests (67%) in the position 2 passed the Nij performance limit.

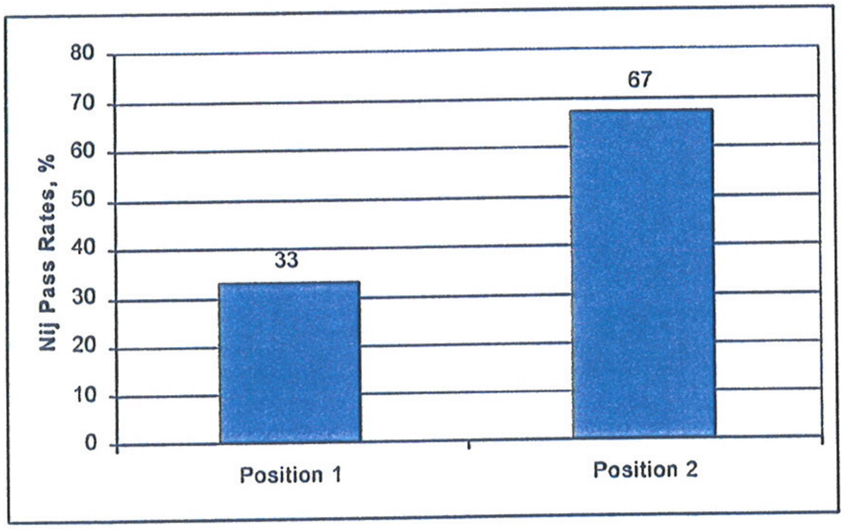


Figure 3-12: Nij Pass Rates for the 5th percentile female dummy in driver position 1 and position 2

Out-of-position data for the six year-old dummy in position 1 and position 2 were also conducted. In addition, to quantify the effect of proximity of the dummy to the air bag module on neck injury, a series of tests in modified position1 in which the dummy is placed 4 and 8 inches away from the air bag were conducted on 1998 model year air bag systems. For the position 1 tests using 1996, 1998 and 1999 model year air bag systems, 2 of 18 tests (11%) passed the Nij criteria of 1.0. For the position 2 tests using a series of air bags from 1999 model year vehicles, 2 of 7 tests (29%) passed (Figure 3-13). The 1999 Acura RL, which has dual-stage passenger air bag, was tested in position 1 and position 2 positions in two ways: (1) firing only the first stage and (2) firing the both stages with a 40 ms delay between the two stages. For the first stage only firing, the Nij values were 0.91 and 0.83 for positions 1 and 2, respectively. For the two stage firing with delay, the Nij values were 1.26 and 0.94 for positions 1 and 2, respectively. Thus, the first stage Acura RL was the only air bag system which passed Nij for both positions.

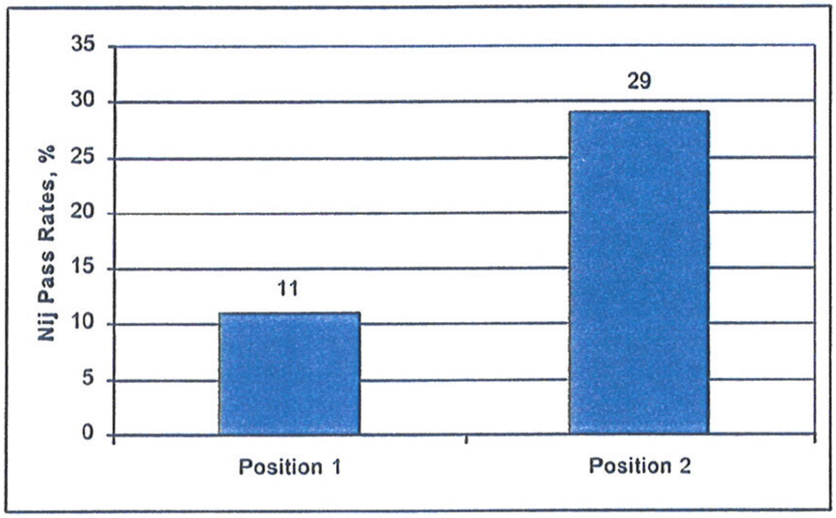


Figure 3-13: Nij Pass Rates for the 6 year-old dummy in child positions 1 and 2

3.5.4 Vehicle Crash Reconstruction Testing

The final set of test data analyzed for this report was from a series of crash reconstructions conducted with a Hybrid III 6-year-old dummy. Three cases involving serious and fatal injuries to a child of approximately 6 years of age were selected from reports prepared by NHTSA's Special Crash Investigation Team. An additional two cases involving only minor injuries were selected from NASS. The three cases involving serious and fatal injuries fail Nij by a wide margin, as demonstrated by their location well outside of the allowable kite shape (Figure 3-14). The two cases involving only minor injuries pass Nij and are within the allowable kite shape.

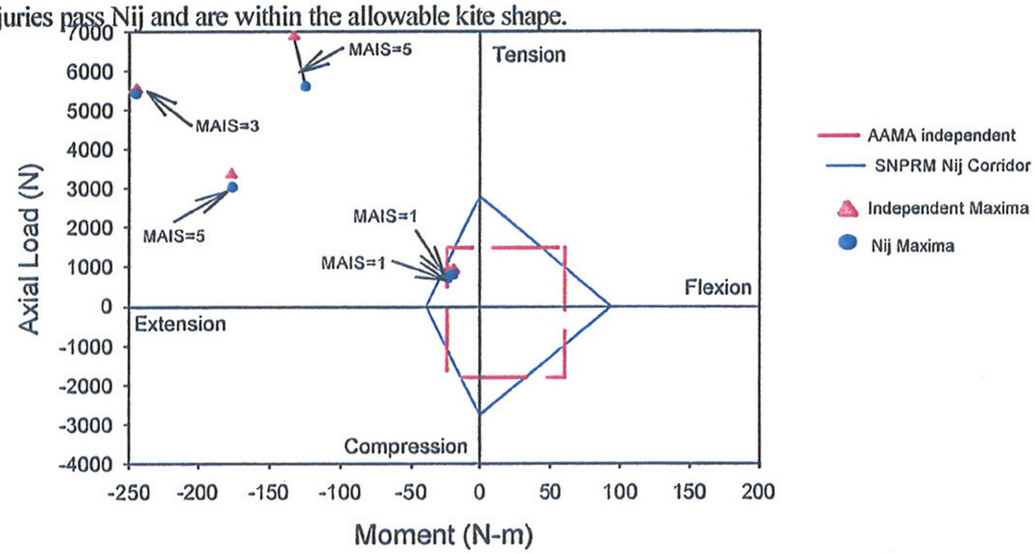


Figure 3-14: Nij for Crash Reconstruction using the 6 year-old dummy

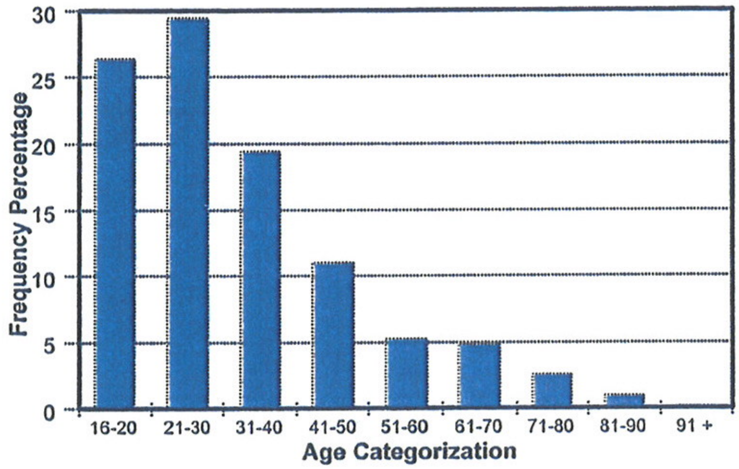


Figure 4-9. Age distribution of the USA driving population exposed to frontal collisions.

The 50% probability of injury line used in the development of the Combined Thoracic Index (Figure 4-7) would represent a significantly lower probability of injury for a car occupant. Figure 4-9 presents the age distribution of the USA population exposed to frontal collisions based on NASS files. The weighted average age of the driving population is approximately 30 years. The average age of the 71 surrogates used in the sled tests is 58 years. Thus, there was a nearly thirty year difference in average age of the surrogate data as compared to that of the average driving population. This thirty year age difference, the increased fragility of cadavers, and the over reporting of injury in experimental tests suggested an adjustment in the probability of injury to represent the probability of AIS• 3 thoracic injury for the average live human driving population. Based on all these factors, the 50% probability of injury line in Figure 4-7 was adjusted to represent a 25% probability of injury level for the live human driving population. The adjusted probability of injury curve written in terms of CTI (defined in Equation 4.2) and the original unadjusted curve are shown in Figure 4-10.

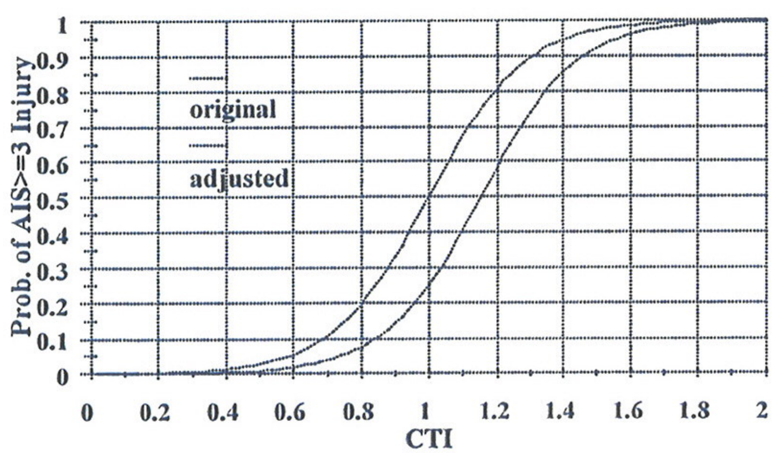


Figure 4-10. Reduced probability of injury using Model VII as the risk factor to relate sled test data to real world crashes. A value of one corresponds to 25% probability of injury.