

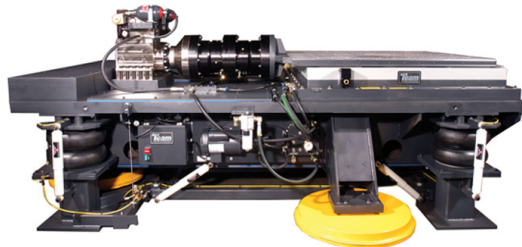
Systems  
&  
Solutions

Engineered  
vibration testing  
solutions for  
improved  
product quality.

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# Horizontal Vibration Test Systems



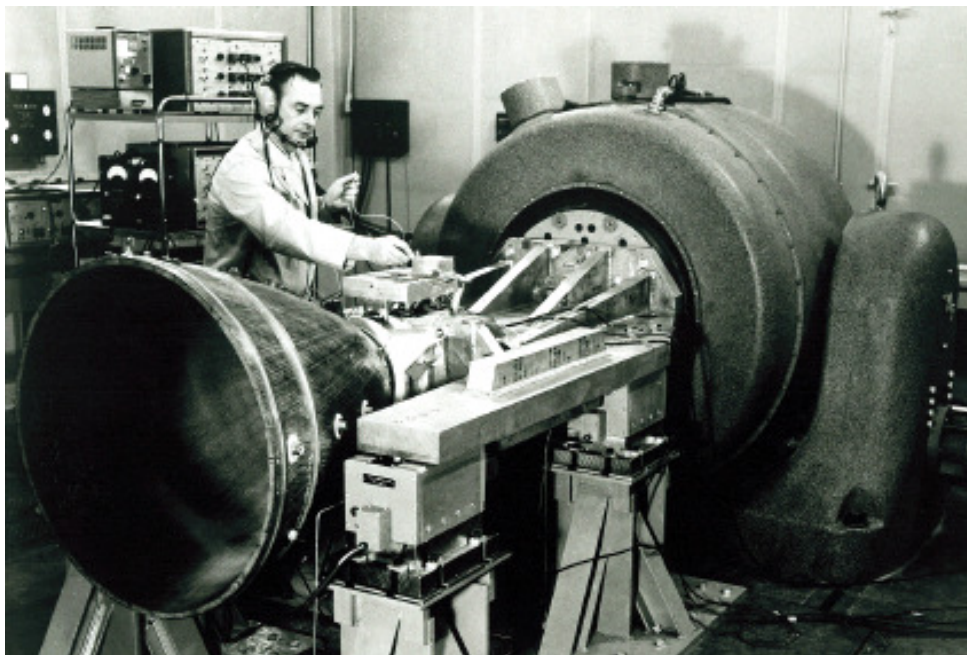
## **Team Corporation Systems Provide the Ultimate Performance in Horizontal Vibration Testing**

Horizontal vibration testing places severe demands upon the bearings guiding the specimen mounting table. The payload must be fully supported and restrained to move in one horizontal axis only, resulting in pure linear motion. *Team* Corporation has developed a wide variety of solutions that approach this goal and has a proven performance record in hundreds of applications.

*Team* Corporation is focused on providing solutions to severe vibration testing requirements. Our heritage extends from the 1950's and includes the design of some of the world's first linear bearing systems used for supporting loads in horizontal test rigs. With the introduction of the T-Film® Slip Table, *Team* Corporation continues this heritage by advancing the state-of-the-art in horizontal test capability.

Our family of hydrostatic slip table systems has been delivered to leading companies throughout the world. Beginning with our Model 1830 hydrostatic linear bearings, through our Model 483 T-Film Slip Table systems, *Team* Corporation continues to be the leading supplier of the most advanced horizontal slip table systems for severe applications.

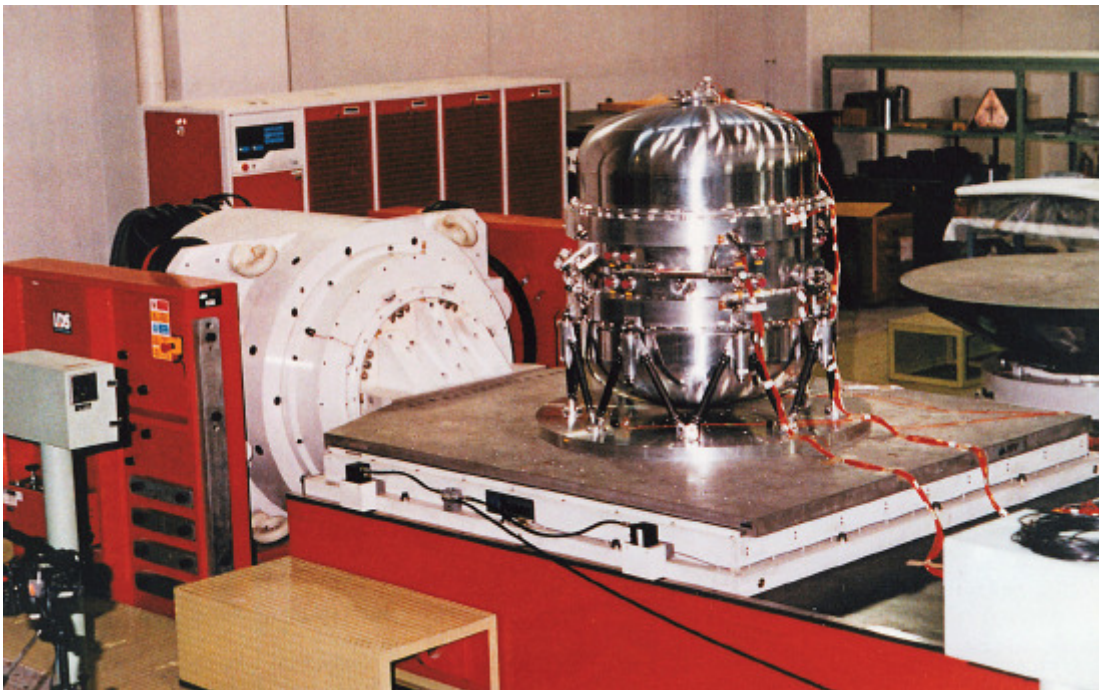
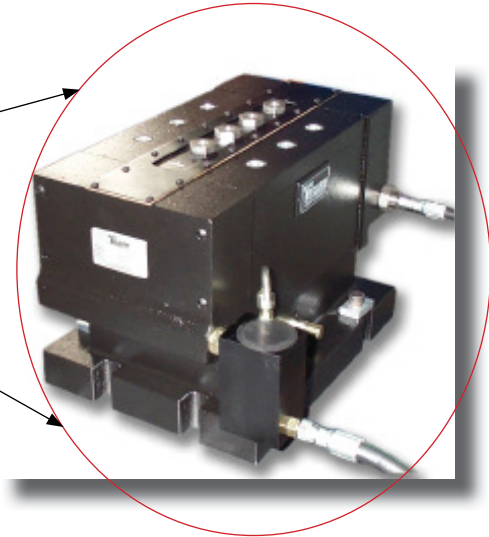
Custom engineering is a hallmark of *Team* Corporation. By offering the widest variety of horizontal vibration test system solutions, *Team* can meet virtually any testing application. Complete flexibility in table sizing coupled with exceptional load support and overturning moment control allows the customer to select the best combination of performance, size and value. All systems utilize hydrostatic bearings, widely recognized as the ideal support and guidance solution for vibration testing. The high load carrying capacity and extreme stiffness of hydrostatic bearings make them perfect for reacting loads for extended time periods. An added benefit is the absence of metal-to-metal contact, eliminating friction and consequently improving long-term performance.



*Archival photo showing Team 1830 bearings supporting a test object being driven through its center of gravity by an electrodynamic shaker.*



*1830 Bearings can be used in multiple quantities to support odd or unique structures for vibration testing.*



*Team T-Film slip tables offer the highest overturning moment capacity of any table on the market. Team's low pressure hydraulic system eliminates potential oil misting problems seen in other bearing systems using high pressure hydraulics.*

## Reacting Off-Axis Motion is Key to Successful Horizontal Testing

Ideal horizontal table design results in one, and only one, direction of motion. Termed a single degree of freedom, the bearings providing this support and guidance must react all off-axis motions. *Team* Corporation has focused on achieving ideal horizontal table performance with exceptional success.

Horizontal excitation of any load generates overturning moments and often yaw moments in response to vibratory input at the base of the load. The key to horizontal table performance is its ability to couple these moments and cross-axis forces into the reaction mass. The horizontal table uses the reaction mass and its rotational inertia to resist these off-axis motions. When the horizontal table is well coupled to the reaction mass, overturning and yaw moments are reacted by the sizeable inertia and very little motion results.

Coupling these moments is the primary function of the linear bearings supporting the slip plate and test load. The ideal bearing would be infinitely stiff in all directions other than the one desired and would be frictionless in the direction of travel. *Team* Corporation linear hydrostatic bearings, with the moving element fully supported by a hydrostatic oil film, approach this ideal design. It is an important point to acknowledge that any bearing acts as a very stiff spring and consequently must deflect to support a load. *Team's* linear hydrostatic bearings are several orders of magnitude stiffer than any other on the market and deflect much less when subjected to loading. Therefore, their ability to couple loads into the reaction mass is much greater, resulting in less off-axis motion. For an in-depth analysis of linear bearing behavior in horizontal test systems, refer to *Team* Corporation's "Technical Analysis of *Team* T-Film Slip Table" available at [www.teamcorporation.com](http://www.teamcorporation.com).

*Team* Corporation offers two basic avenues for creating the best horizontal slip table solution, based upon customer requirements and existing facility infrastructure. The first makes use of individual, linear hydrostatic bearings that can be configured in almost any arrangement to accommodate awkward payloads. The second are complete slip table systems that can be built to any combination of width and length up to approximately 10 feet in either direction. Both types of solutions have been fully field proven, offering exceptional performance and robust construction.



*Team 484 bearings come in a variety of stroke lengths. Developed from *Team's* patented T-Film bearing, the 483 bearing uses low pressure oil and can be used much like the 1830 bearing.*

# Self-Contained Linear Hydrostatic Bearings Offer Complete Flexibility in Configuraton

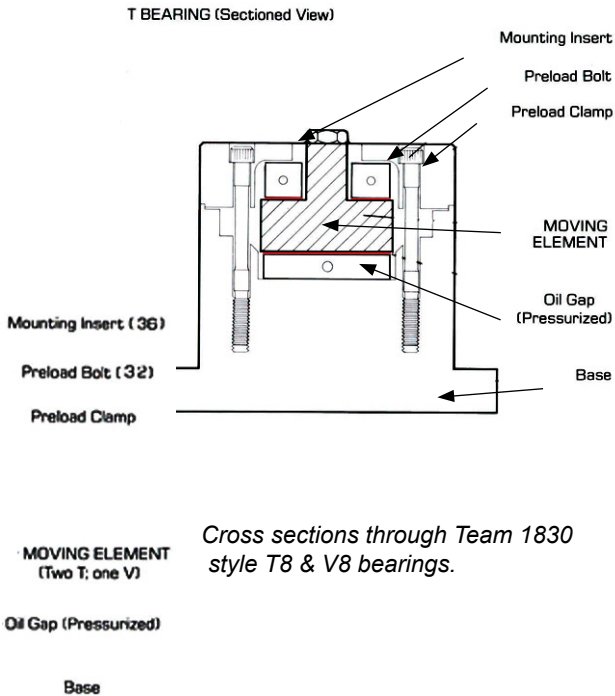
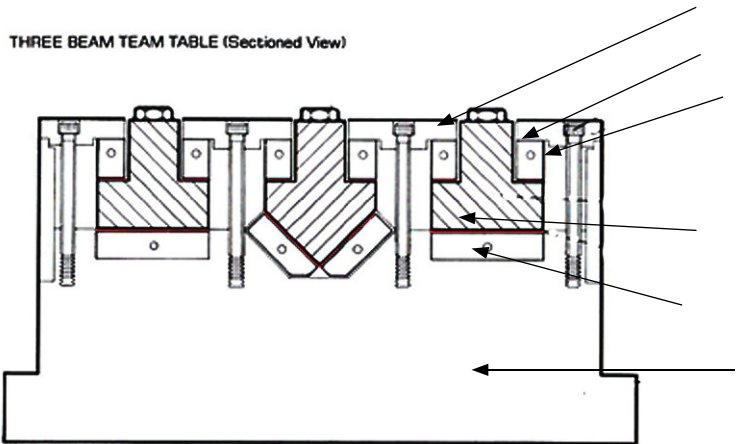
Conventional horizontal slip tables are generally offered in a discrete array of sizes. Through the use of *Team* individual linear bearings, it is possible to configure a horizontal test system based upon the payload or fixture design, using only the number of bearings ideally placed for optimum performance. And the bearings can be easily rearranged to accommodate new payloads with different fixturing or dimensions.

*Team* Corporation developed a family of linear hydrostatic bearings to provide a flexible collection of slip table components able to accommodate a changing array of test objects. The bearings are individual units, capable of being placed anywhere on a flat, rigid surface under the test load or test fixture. An array of bearings can be used to support a large slip plate on which payloads are secured or bearings can be used to directly support a fixture at key locations. Several models of bearings have been produced with the Model 1830, V8 and T8 being the most common size. Originally available in a stroke length of 1.25 inches, to match the stroke of available electrodynamic shakers, Model 1830 bearings are now available in many different stroke lengths. *Team* instituted an upgrade program to increase the stroke of our original 1830 bearing from 1.25 inches to 2.5 inches, giving test labs an economical means to safely use their existing equipment with current electrodynamic shaker capabilities.

Application of these bearings is only limited by the imagination of the user. Large, asymmetrical fixtures or payloads can be mounted directly to the precision inserts on the moving element, permitting horizontal vibration of loads not well suited for conventional slip table design. Bearings can be used to enhance the utility of an existing slip table for over sized payloads when used as extensions to support the payload overhang. With their huge moment load capacity, *Team* bearings can safely test payloads with very high and large centers of gravity. Each bearing has a static load capacity of approximately 10,000 lbs which makes it possible to

support and guide incredibly massive loads with safety and accuracy. Model 1830 bearings can be mounted to support vertically excited loads and can even be used to suspend a load to replicate actual field installations, for example, a munitions package slung under the wing of an aircraft.

A new addition to the self-contained bearing family is based upon our innovative T-Film technology. This patented line of bearings is *Team* Corporation's Model 484 series, available in virtually any stroke length. Designed to use only 600-psi hydrostatic oil pressure, the risk of any oil mist due to seal failure is virtually eliminated. These bearings are economical to manufacture while still providing exceptional performance benefits. The long stroke capability opens a route to innovative testing systems. For example, they are well suited to the very long stroke needed to replicate the ground motions of seismic events, while supporting dimensionally large and massive payload structures.



Cross sections through *Team* 1830 style T8 & V8 bearings.

# Team Corporation's T-Film® Slip Table Provides the Ultimate Performance in Horizontal Vibration Testing

Team Corporation's T-Film Slip Table was conceived from the outset to provide the ultimate in horizontal slip plate performance. Based upon our unique and patented T-Film Bearing design, these slip tables have a proven track record with our most demanding customers throughout the world.

Team Corporation developed the T-Film Slip Table to solve the inherent technical limitations of conventional hydrostatic journal bearing tables. The design has been proven superior in the most severe testing applications. Unique to this design is the ability of the T-Film bearing system to react extreme overturning moments without resorting to a high-pressure oil supply. The use of low-pressure oil in the hydrostatic bearings makes this system the best choice for satellite, optical and other test regimes where control of oil mist is critical. The following defines some of the advantages of the T-Film Slip Table:

- **Extraordinary Load Capacity. The T-Film**

Table utilizes low oil pressure bearings combined with an oil film to provide a load capacity which exceeds the capacity of conventional high-pressure journal bearing/granite slip table systems.

- **Best Vertical Cross-Axis Control.**

The unique T-Film design provides an oil film surface area, which exceeds the nominal table area by 27%. All other designs available today reduce the nominal oil film table area by as much as 20%. The increased oil film area provides excellent control of vertical cross-axis motions as well as increased damping of high frequency resonance.

- **Outstanding Dynamic Stiffness.**

The direct load path from the slip plate to the base provides a much stiffer table system than a typical journal bearing table. The very large oil film area also contributes to this superior stiffness.

- **"All Bearing" System.**

Evenly distributed bearings are located directly below the slip plate mounting surface. No other bearing table system offers as many bearings per surface area. For example, a standard 60-inch square table has 25 bearings. No matter where the test article is mounted on the table, it is always supported by 'load carrying' bearings.

- **Low Pressure Oil System.**

Low-pressure oil is ported through the base, eliminating the need for oil ports in the slip plate. No expensive high-pressure pump is required. The 600-psi pump system is included with the T-Film Table.

- **Oil Mist Control.**

Preventing hydraulic oil from escaping the table and possibly contaminating the test article is easily accomplished with the T-Film Table design. Team's bearing design has eliminated all high-pressure seals, which minimizes the chance of oil atomization. Continuous wipers remove any oil carried by the underside of the table.



Several sizes of T-Film slip table mounted on combi bases for electrodynamic shakers.

• **Reduced Maintenance.**

Using low-pressure oil supply eliminates the need for high-pressure dynamic seals. Failure of these dynamic seals is the root cause of most of the maintenance requirements in journal bearing tables. Team T-Film tables have operated in the field with literally no periodic maintenance for years.

The 483 T-Film slip table systems are based upon our modular T-Film Hydrostatic Bearing elements. The moving slip plate of the table can attach to either a new or existing vibration exciter. Each bearing element is nominally 12 inches by 12 inches and is designed to support a slip plate area of the same size. Virtually any size/shape slip table required can be produced.

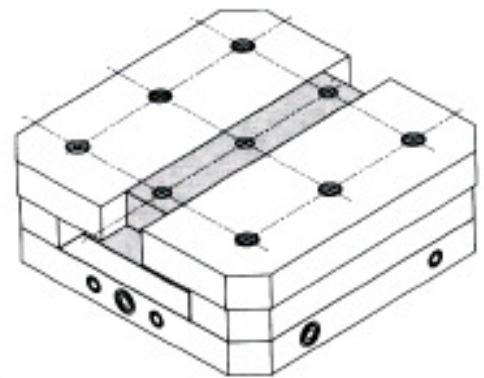
To achieve the customer's required overturning moment in the pitch and roll directions, an array of bearings is selected – quantity to be defined by the test requirements. The array proposed is designed to provide the needed static and dynamic support yet minimizes moving weight. In order to reduce the moving weight of the system, *Team* generally proposes a mix of T-Film elements and oil film elements. Each T-Film element used in the array adds 10.2 lbs. to the moving weight. The T-Film bearings have such large load capacity (each bearing can statically support 6,500 lbs.) that it is often possible to reduce the total moving mass while maintaining a comfortable operating margin for static and dynamic support.

The oil film elements support the slip plate exactly as a granite slip surface. They are physically the same size as the bearing elements except that they do not have a moving element capable of reacting upward loads. These oil film elements are designed to bolt down exactly as a T-Film bearing element and may be replaced at a future date with a full bearing element to increase the capacity of an existing table installation.

In some cases it is necessary to include special bearings to react large yaw moments. The High Yaw bearings are necessary if the test object has, for example, an large eccentric center of gravity. In this case the test profile may create a large rotational moment around the vertical axis of the table. Reacting this high yaw moment requires special bearing designs that have successfully demonstrated the ability to handle large loads.

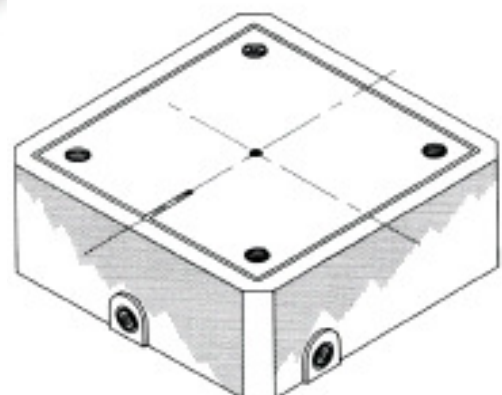
Although it may seem more bearing elements are used than are required, the additional wetted surface adds considerably to the overall system damping. This results in a system that is much more tolerant of test article resonance, allowing both very low level tests and high level tests with better control.

**T-Film Bearing**



*483 T-Film® Slip table with slip plate removed to show bearing array.*

**Oil Bearing**



## Integration of Exceptional Components into a Complete System Solution is a *Team Corporation* Specialty

Supplying top-quality components does not solve test system design challenges. Combining components into a complete and versatile test machine is the hallmark of *Team's commitment to systems excellence.*

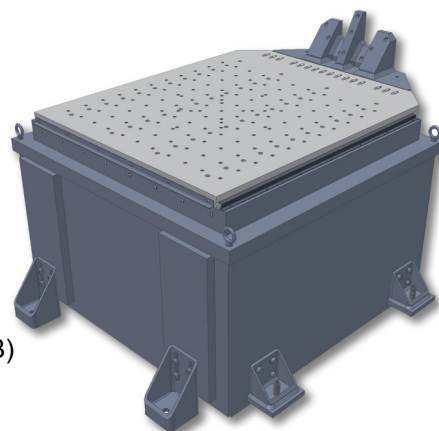
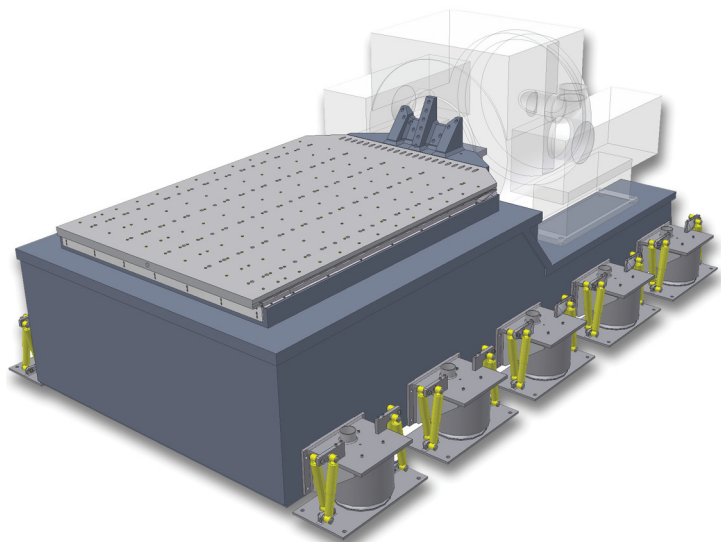
The key to horizontal system performance is the ability to couple reaction forces into the system base. This base plays an important role in the dynamics of the system since its mass and rotational inertia are used to resist overturning moments and cross-axis motions of the load. The stiffness of the bearing connecting the load to the reaction base is critical to this coupling and *Team Corporation* has proven hydrostatic bearing designs that are several orders of magnitude stiffer than any other bearing system available.

With this exceptional increase in bearing stiffness, the dynamics of the reaction base become more apparent in system response. Therefore, the design and construction of the base supporting the bearing array must be carefully considered. *Team Corporation* has produced dozens of bases for both electrodynamic and servo hydraulic shaker systems that have been proven in the field to provide the requisite characteristics of stiffness and well-damped response.

A typical *Team* base is constructed from very heavy steel plate, fully welded into a rigid box-beam configuration, and filled with high strength concrete. If the customer selects one of *Team's* T-Film Slip Tables for horizontal excitation, the table is built as an integral feature of the base, not merely bolted on to its top surface. Several transverse stiffening members are incorporated under the bearing array to support the static vertical load and to provide the optimum load path for dynamic loading. In our Trunnion Reaction Base (TRB) design, where the shaker is mounted onto the

base and can be rotated from vertical to horizontal, the TRB acts as the reaction mass. It is fitted with air isolators to minimize the transmission of energy into the laboratory floor. On our Riser Base (RB) design, where the shaker is mounted to a reaction mass in the laboratory floor, the typical base is supplied with both leveling and substantial tie-down feet. This combination easily accommodates

*Team* Trunnion Reaction Base (TRB)



*Team* Riser Base (RB)



both lateral and angular alignment of the Riser Base and integral T-Film Slip Table to the shaker armature while ensuring this alignment does not change over time. The selection of which system is most appropriate to testing requirements is driven by the existing installation and the expected dynamic response of the payload. For example, a test object with a high center of gravity can produce an unacceptable lateral rocking mode when performed on a TRB fitted with air isolators. Increasing the mass of the TRB, with an attendant increase in system cost, can minimize this reaction. *Team* Corporation's engineering staff can assist the customer with an analysis of cost versus performance issues.

When using a T-Film Slip Table with an electrodynamic shaker, the connection between the shaker and the slip plate is critical to system performance. The *Team* Drive Adapter (DA) was designed to provide a fast, foolproof connection that does not require a high level technician for proper installation. It allows very fast change over from vertical to horizontal when using a large force shaker system.

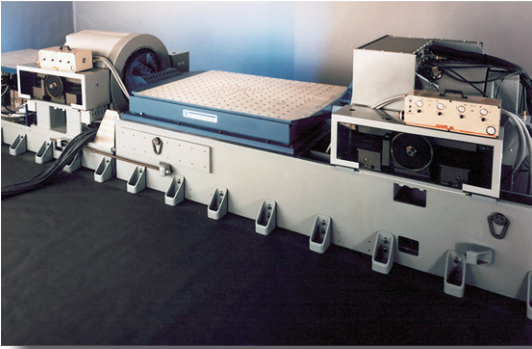
Each DA manufactured by *Team* is a magnesium (AZ31B) weldment. The main feature of this drive adapter is that the DA to slip plate interface is a preloaded connection. This connection does not use expanding pins with elements in shear. If a connection has to depend upon a shear joint to transmit the force, the contacting surfaces should be about 3 times the area of a tension/compression connection. The reasoning here is that the shear modulus is only 37% of the tensile modulus, therefore a connection of equal stiffness using a shear joint must contain at least 2.7 times the contact area that a tension/compression joint requires.

The transmissibility of the drive adapter to slip plate interface will be warranted to be as good as the transmissibility of the shaker armature to drive adapter interface. The surface area of the *Team* connection is much greater than that of the shaker interface and therefore is much stiffer. This type of connection reduces the possibility of introducing vertical cross axis motion to the slip plate. Another feature of this drive adapter is that it starts to flare out to the width of the slip plate right at the shaker face rather than being a straight adapter piece. This means that more of the shaker force is available to reach the near corners of the slip table, resulting in more uniform slip plate excitation.

All of the bolts that attach the slip table to the drive adapter are accessed from the top surface of the table. When rotating the shaker from horizontal vibration to vertical vibration, all that is required is to remove the attachment bolts from the drive adapter, pressurize the slip table, and move it to its fully extended position by hand. This will provide enough clearance for the shaker to be rotated without interference from the slip table.

*Team* Drive Adapter (DA)





### **Sundstrand Twin Trunnion Reaction Bases.**

Dual trunnion reaction bases using two 40,000 lbs electrodynamic shakers. Each table can be driven from both ends simultaneously. The larger table is built with 483 T-film bearings, the smaller with individual T-8 and V-8 pedestal bearings. The reaction bases both incorporate air bearings allowing them to be floated to different positions on the customer's reaction mass.



### **ComputaLog Horizontal System**

The dedicated horizontal system shown can perform a 20 Grms random profile, flat from 5 Hz through 500 Hz on payloads up to 6 feet long. Typical system tests require 8 hours of continuous operation. The combination of *Team* Corporation's HydraShaker design and T-Film® Bearings has proven to provide the ideal solution to this tough requirement.



### **Boeing 483 T-Film Table.**

Modular construction allows different size slip plates to be used on the same shaker system to match shaker capacity and payload. The table is shown with the smaller slip plate mounted. The black cover surrounding the slip plate can easily be removed and the larger slip plate mounted.

## Team Corporation's Service and Support Group Ensures Test System Availability

Testing programs can be severely affected by downtime due to system maintenance or repair. *Team Corporation* provides the customer with unmatched reliability. In the event of a breakdown, *Team's* dedicated service engineers are able to provide effective support in a timely and cost effective manner.

### ***Team Corporation's Service and Support Group ensures test system availability***

Testing programs can be severely impacted by downtime due to system maintenance or repair. Friction-free hydrostatic bearings require no periodic mechanical adjustment, which provides the test lab with unmatched reliability. In the event of a breakdown, *Team's* dedicated service engineers are able to provide effective support in a timely and cost effective manner.

A test system is only effective if it can be used when needed. Periodic maintenance must be anticipated and carefully planned to minimize program interruptions. *Team Corporation* test systems, using hydrostatic bearings, eliminate the most common sources of periodic maintenance. No longer is it necessary to replace high pressure seals. What has been a regular service requirement on typical systems is now fully eliminated.

First and foremost, *Team Corporation* offers annual maintenance contracts to ensure a consistent level of system availability. In the event of unanticipated service requirements, *Team* can dispatch service engineers to provide more extensive maintenance as needed. To augment our customer support function, fully capable service is available locally at select sites.

The only regular maintenance consists of hydraulic filter element replacement. *Team* has established a policy to provide filter element model numbers as defined by the filter manufacturer, allowing the customer to procure these items locally.



*Patented Team T-Film bearing.*

Of course, *Team* also maintains an inventory of these items to ensure continual availability for the customer's convenience.

### ***Tell Team Corporation Your Needs***

Personal and confidential service is the cornerstone of *Team Corporation's* commitment to systems excellence. Contact *Team Corporation* directly to see if one of our standard designs is right for your application. Your system needs will be reviewed by our staff of engineering experts. With over 35 years of experience dealing with horizontal test system solutions, *Team* brings a wealth of knowledge to the discussion, suggesting alternative design options to maximize your system capabilities. Let *Team* become your partner in system solutions.



*L to R: Bill Woyski, VP of Research & Development; Doug Lund, VP of Engineering; Bob Tauscher, CEO; Bruce Huntley, General Manager.*



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