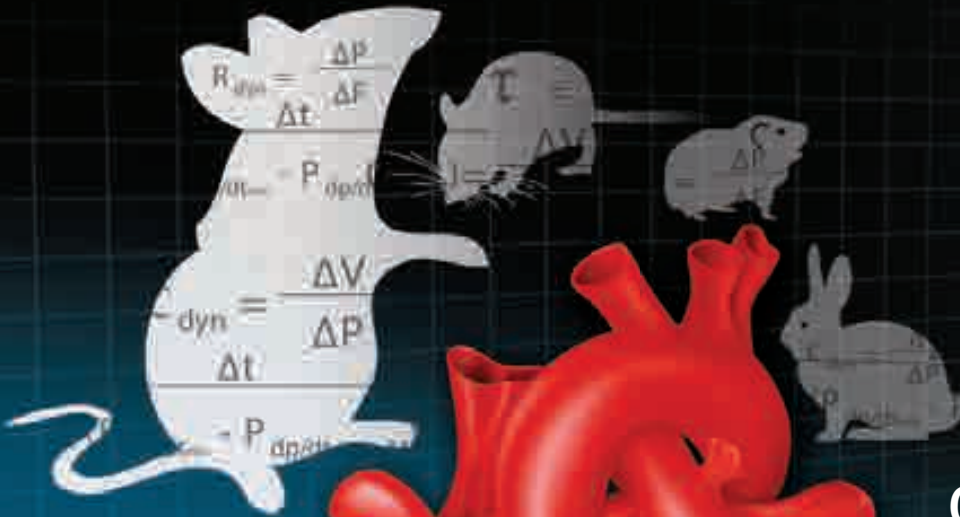


Isolated Heart Perfusion Systems

for mouse to rabbit animal models



Cardioplegia

Refractory Period

Tissue Engineering

Contractility Studies

Safety Pharmacology

Cardiovascular Screening

Myocyte Harvesting & Isolation

Electrophysiology (ECG, MAP)

Phenotyping of Transgenics

Ischemia and Reperfusion

Ex Vivo Perfusion

Cardiac Mapping

Hemodynamics



HUGO SACHS ELEKTRONIK

The Physiology Specialists

HARVARD

APPARATUS



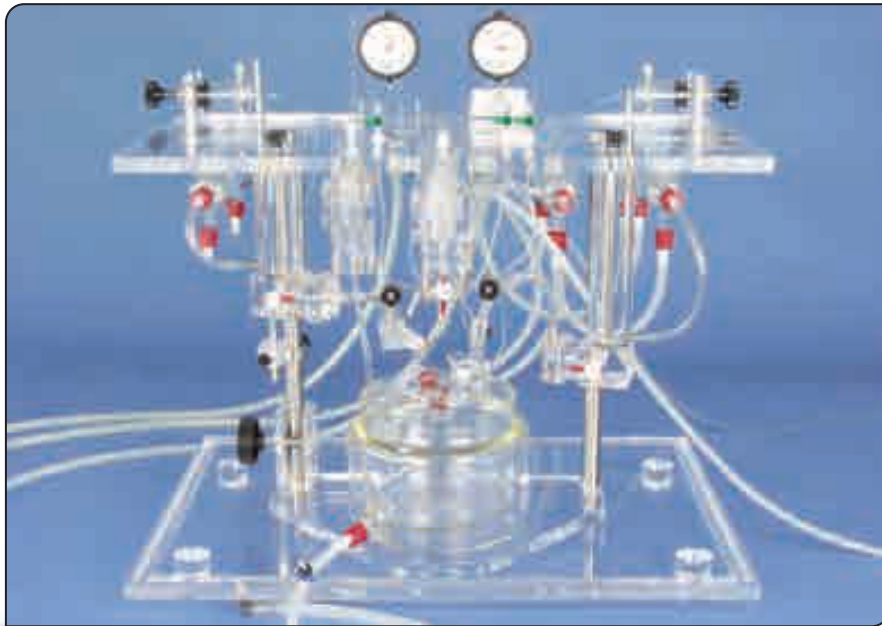
HUGO SACHS ELEKTRONIK

The Physiology Specialists

HARVARD
APPARATUS

ISOLATED HEART PERFUSION SYSTEMS BY HUGO SACHS ELEKTRONIK – HARVARD APPARATUS

Hugo Sachs Elektronik, a Harvard Apparatus company, has always provided top-notch, fully integrated physiology research systems. Continuing our tradition of innovation and high performance we are happy to unveil the newly configured line of Isolated Perfused Heart Systems for rodent and rabbit models. For two decades the Hugo Sachs Elektronik IH-Series of Isolated Heart Systems has been the gold standard for cardiac physiology measurements in both Langendorff and Working Heart perfusion modes. Today the IH-Series continues to lead the way with an expanded range of measurement capabilities and the introduction of the **NEW** Biventricular Working Heart system, breaking new ground in *ex vivo* cardiac research.



WHAT MAKES THE IH-SERIES SO REVOLUTIONARY?

What makes the IH-Series unique is the revolutionary Perspex construction which simply cannot be matched. The use of Perspex instead of traditional glass allows our engineers to mill the perfusion pathway directly into the solid Perspex blocks. The result is what we call a Solid State Physiological Perfusion Circuit (S²P²C). This patented perfusion technology ensures a precisely repeatable non-turbulent perfusion pathway for the highest fidelity pressure and flow measurement. This, combined with the naturally excellent thermal properties of Perspex, creates a system that allows control, maintenance and monitoring of circulatory parameters in a way that is more physiologically relevant than any conventional perfusion system.

SPECIES GUIDE FOR THE ISOLATED HEART SYSTEM



Mouse



Rat



Guinea Pig



Small Rabbit

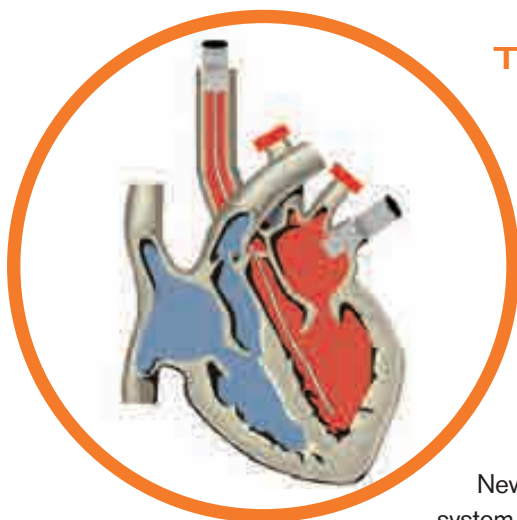
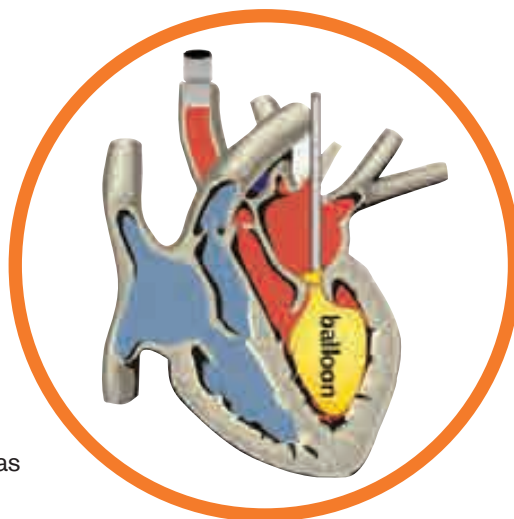


Rabbit

These icons will help guide you to which species can be used with each system.
Above is a sample of the animal icons you will see throughout this brochure

THE LANGENDORFF SYSTEM

The IH-Series *Ex Vivo* Perfused Heart Systems always start as a Langendorff system. This means a configuration solely for retrograde perfusion down the aorta (toward the heart). In this mode, the aortic valve prevents the perfusate (nutrient solution) from entering the left ventricle, but the coronary arteries are perfused via the coronary ostia which are located just outside the valve, thus maintaining the viability of the heart muscle. Perfusate drains as effluate from the coronary circulation via the coronary sinus and pulmonary artery tends to drip from the apex of the heart making it easily available for collection. The IH system configured in this way provides an excellent platform for basic applications such as cardiomyocyte isolation as well as for physiological monitoring using the robust Langendorff assay where perfusions of several hours are typical.



THE WORKING HEART SYSTEM

The modular nature of the IH-Series allows for initial integration or later upgrade with the Working Heart (also known as Ejecting Heart) perfusion pathway*. This enables orthograde perfusion: entering the left atrium, flowing through the left ventricle and exiting the aorta. In this way, a more physiological assay of ventricular contractility is possible as the left ventricle is now fully-ejecting and performing pressure-volume and acceleration work. In order to fully exploit this advantage, the IH-Series includes a specialized pathway which easily allows introduction of a Pressure (LVP) or Pressure Volume (LV-PV) catheter directly into the left ventricle via the aorta, rather than via apical puncture.

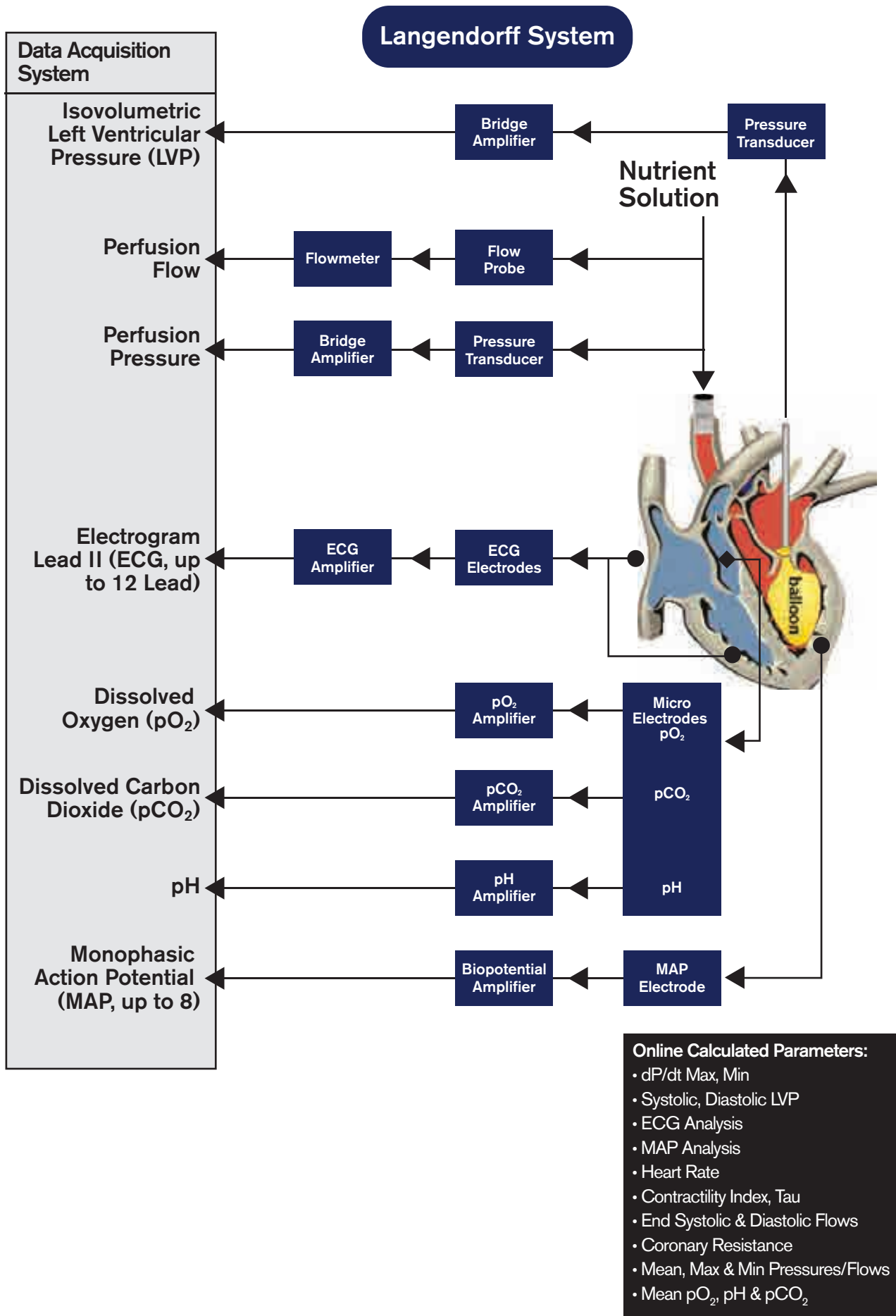
New to our IH-Series, introduced here, is a Biventricular Working Heart system which allows for *ex vivo* studies of diseases characterized by pulmonary vascular dysfunction and right heart pathophysiology. The system employs unique flow resistance and compliance chambers to faithfully mimic the *in vivo* cardiac preloads and afterloads for both normal and diseased states. In addition to the ejecting left heart, which is now supplying perfusate to the coronaries and thus maintaining heart muscle viability, the right heart is also performing the low pressure ejection, whereby the perfusate enters the right atrium, flows into the right ventricle and exits through the pulmonary artery. Additional measurements of Right Ventricular Pressure (RVP) or Right Ventricular Pressure-Volume (RV-PV) can now be taken independently or simultaneously with LVP/LV-PV.

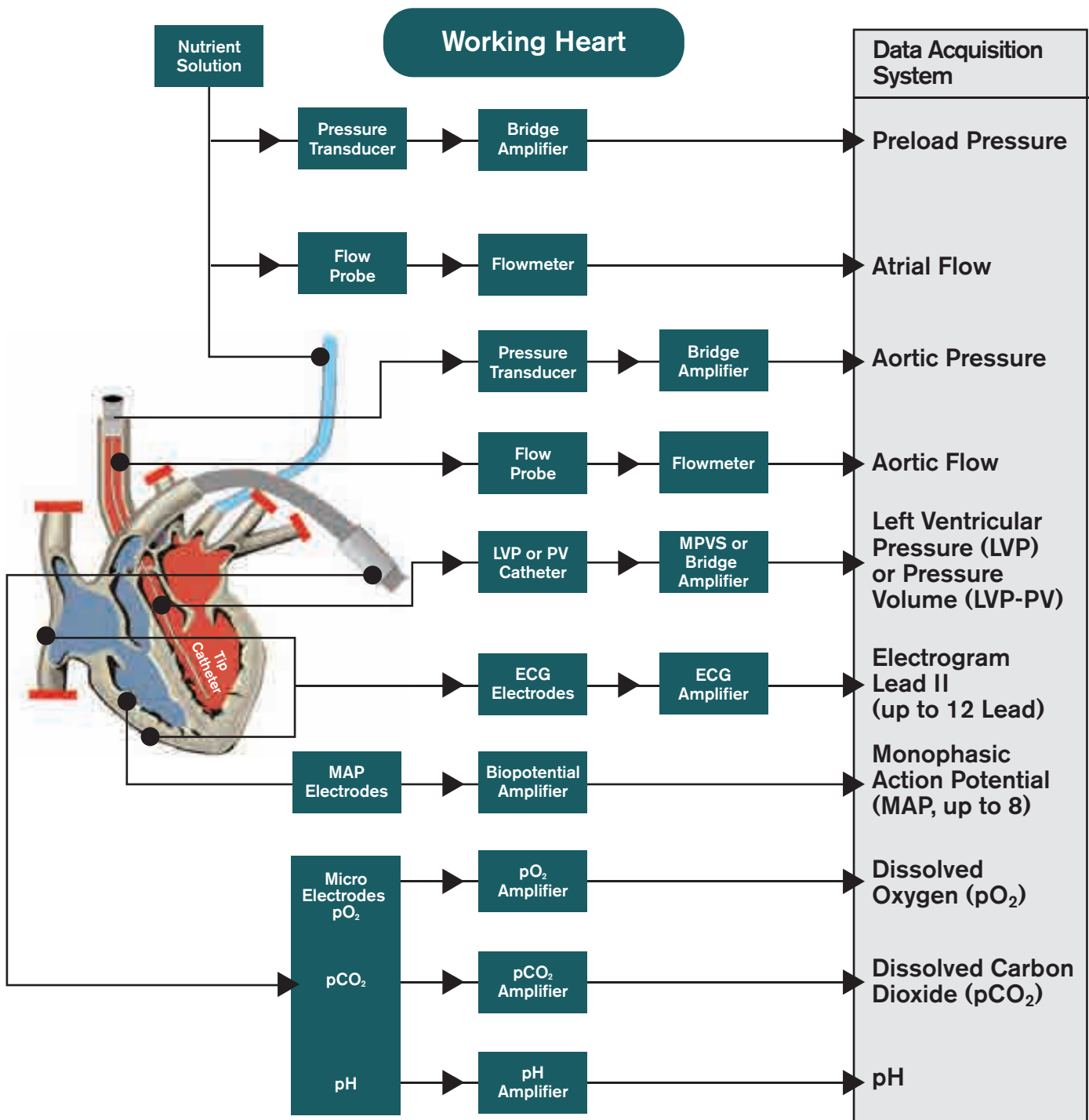
In either configuration, the IH-Series can be outfitted as a complete Cardiac Physiology Workstation with a range of measurement devices, signal conditioning equipment, and acquisition & analysis software to provide a superior solution for virtually any study.

To get started, select the basic system for your species model then add specific options to suit the particular needs of your study. Use the **NEW** configuration checklist and worksheet on pages 76-77 to create your custom system. If any questions arise, our expert technical team of scientists and engineers is always ready to assist with system configuration, application support, and custom design requests.

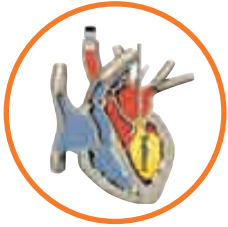
* Certain systems described in this guide are limited to Langendorff-only configurations (UP-100LD, PSCI, EasyCell).

Langendorff and Working Heart illustrations in this guide are used with permission courtesy of SANOFI-AVENTIS, Germany.



**Online Calculated Parameters:**

- dP/dt Max, Min
- Systolic, End Diastolic LVP
- PV Parameters
- ECG Analysis
- MAP Analysis
- Contractility Index
- Coronary Resistance
- Coronary Flow
- Mean, Max & Min Pressures/Flows
- Mean pO_2 , pH & pCO_2
- Mean Cardiac Output, Aortic Flow
- Heart Rate
- End Systolic, Diastolic Flows



Langendorff Systems

UP-100IH BASIC LANGENDORFF

The UP-100IH Basic Langendorff perfusion system is primarily for rat, guinea pig, and juvenile rabbit heart, though it can be used for mouse heart as well. It has a small footprint, making it ideal for multi-channel compound screening that can incorporate measurement of basic cardiac parameters such as LVP and ECG.

SEE PAGES 8-13



IH-SR LANGENDORFF

The IH-SR Isolated Heart for Small Rodents, Langendorff Only, is designed to be used for rodent models mouse, rat, and guinea pig exclusively in the Langendorff retrograde perfusion mode. Because of the larger heart chamber this system is well-suited for assays that require multiple lead ECG and MAP in addition to LVP and pacing. The fully-closing heart chamber allows for much more precise temperature control, making it the optimal choice for mouse heart perfusion. A Working Heart-Ready configuration is also available. All IH-SR package options, including the IH-SR Working Heart Expansion, are available for this configuration.

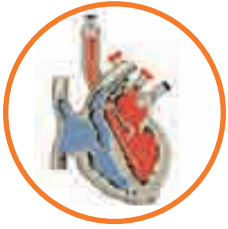
SEE PAGES 14-23

IH-5 LANGENDORFF

A Langendorff retrograde perfusion system for rat, guinea pig, and rabbit models. Like the IH-SR the IH-5 system does not utilize high water columns but creates a constant pressure perfusion setup using a pressure feedback pump controller, resulting in a compact system fully within reach of the researcher. A special addition is available that incorporates multi-lead ECG and multi-Monophasic Action Potential recordings to create a cardiac electrophysiology workstation. A Working Heart-Ready configuration is also available. All IH-5 package options, including the IH-5 Working Heart expansion, are available for this version.

SEE PAGES 24-35





Working Heart Systems

IH-SR WORKING HEART SYSTEM

The Working Heart model is the ultimate *ex vivo* physiological model. The IH-SR Working Heart allows the researcher to take full advantage of this model with physiological simulation that cannot be matched in small rodent preparations. With the built-in patented Physiological Afterload System (Starling resistor), the need for the conventional water column is eliminated. The result is vastly improved arterial pressure evaluation without the risk of damage to heart valves.

SEE PAGES 36-41



ISOLATED HEART PERFUSION SYSTEM



IH-5 WORKING HEART SYSTEM

The IH-5 Working Heart system provides a valuable tool for the researcher who wishes to study cardiac function and metabolism. Because the heart is fully ejecting, it is possible to accomplish a more comprehensive monitoring of functional parameters and the calculation of external heart work and mechanical efficiency. The proprietary afterload system eliminates water column bouncing, reducing stress and damage to cardiac valves.

SEE PAGES 42-46

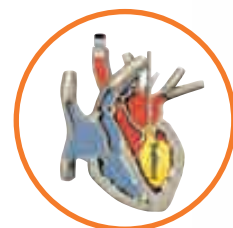
BIVENTRICULAR WORKING HEART SYSTEM

The Biventricular Working Heart System is the only *ex vivo* heart perfusion system for both the right and left heart capable of mimicking the *in vivo* physiological environment without the need for high water columns and compliance tubing. This is accomplished by the use of the patented membrane afterload resistor and built-in compliance membranes which faithfully reproduce physiological peripheral and lung resistances and compliances. The system is also based on our Solid State Physiological Perfusion Circuit technology providing strong thermal stability and laminar flow. This system is appropriate for studies requiring both the right and left heart to be ejecting and performing heart work in order to obtain a full set of meaningful data. Where previously this could only be accomplished with high fidelity *in situ*, the capability is available as an *ex vivo* preparation that is removed from the confounding influences of the central nervous system.

SEE PAGES 47-52



UP-100IH Universal Perfusion System



HEART CHAMBER

- Small Heart Chamber For Temperature Maintenance
- Precision Ball-Joint System for Secure Positioning of Electrodes
- Perfusion Pressure Measurement Proximal to Aorta

PERFUSION PATH

- Compliance Chamber for Pressure Pulse Dampening of Peristaltic Pump
- Primary and Secondary Bubble Traps Protect Against Embolism, Ensure Vascular Integrity
- System Volume is <20 ml, Reducing Temperature Loss and Mixing of Test Compounds

PLUGSYS

- Modular Amplifier System
- Low Noise, Analogy Fidelity and Control
- Compact, Space-Saving Arrangement
- Output Signals to Virtually Any Data Acquisition System

BASIC MEASURED PARAMETERS

- Perfusion Pressure
- Isovolumetric LVP

UPGRADEABLE FUNCTIONALITY:

- ECG Lead II
- Pacing
- Direct or Indirect Coronary Flow Measurement
- Temperature Measurement
- Metabolic Monitoring
- Drug Application
- Cell Isolation Addition

FEATURES:

- Most Compact Langendorff Design
- Versatile Perfusion System can be used for *In situ* or *Ex vivo* Perfusion or Liver, Kidney and Other Organs and Tissues
- Small Bench Footprint Allows Setup of Multiple Systems for Increased Throughput

UP-100IH: Most Popular System for Multi-Channel Compound Screening



FEATURES & BENEFITS

- **VERSATILITY:** The Universal Perfusion System UP-100 can be outfitted for use as an *ex vivo* or *in situ* perfusion system for any small animal model organ (heart, liver, kidney, and more) and is the ideal economic choice for the cost-conscious physiology/pharmacology lab with the need to screen drugs for safety pharmacology and toxicology in multiple organs.
- **SAFETY:** Compact system generates constant pressure perfusion with no high water columns - no climbing on stools to place a heavy water-jacketed reservoir at a high level for creating constant pressure head.
- **CONVENIENCE:** New UP-100IH System packages simplify the process and reduce the costs of setting up a Langendorff system in the lab by allowing the researcher to focus on their application requirements and choosing the options for their parameters of interest rather than having to spend time sourcing individual support equipment components and worry about compatibility.

UP-100IH

The UP-100IH is the preferred system for compound screening that requires the basic measured parameters such as simple Left Ventricular Pressure (Isovolumetric LVP), ECG Lead II measurements, and temperature. Therefore the more common configuration of this system will be the UP-100IH Basic which allows the researcher to measure 2-3 parameters in addition to those that are included in the standard system (Aortic Pressure and LVP). Most researchers will also want to operate in a constant pressure perfusion mode and measure coronary flow, which is a simple addition to the basic system.

The UP-100IH Advanced system allows up to the full range of available measured parameters beyond the basic system including direct coronary flow, ECG lead II, temperature measurement, and metabolic parameters (pH, pO₂, pCO₂).

All UP-100IH systems can be used for constant pressure or constant flow perfusion of isolated hearts of mice, guinea pigs, rats and newborn rabbits as long as the coronary flow is below 50 ml/min. Constant pressure perfusion is achieved by the optional addition of a controller (SCP) which modulates the flow generated by the perfusion pump based on a perfusion pressure feedback loop. The controller also provides an accurate, low-cost way to indirectly measure coronary flow. The system can be adapted for direct, real-time coronary flow measurement allowing the study of myogene autoregulation (reactive hyperemia) if required.

Whether you are isolating cardiomyocytes following a physiology experiment or require occasional cardiomyocyte isolation in addition to the standard Langendorff assays, the Cell Isolation option to the UP-100IH will satisfy your requirements. Other useful add-ons include drug addition using a syringe pump and pacing. If perfusate containing albumin or erythrocytes is used, the oxygenation can be optimized with the addition of a fiber oxygenator.

The complete system includes virtually everything you need to accomplish the basic Langendorff experiment, only requiring the addition of the appropriate species-specific package and the desired data acquisition system. For detailed descriptions of system extensions and options see pages 11-13, 53-60. Contact our expert technical team if you need assistance with system configuration, application support or custom design requests.

MEASURED SIGNALS & PARAMETERS ON THE UP-100IH BASIC SYSTEM:

The following signals are recorded as raw data:

- Isovolumetric Left Ventricular Pressure (Balloon Method)
- Aortic (Perfusion) Pressure

The following parameters are calculated from the raw data (using a DAQ System):

- dLVP/dt, dLVP/dt Max, dLVP/dt Min, Contractility Index
- Systolic and Diastolic LVP
- Heart Rate
- Mean Perfusion Pressure

UP-100IH: Core Systems

UP-100IH Core System, Basic:
73-4384 (115V) or 73-4385 (230V) ●●●●●

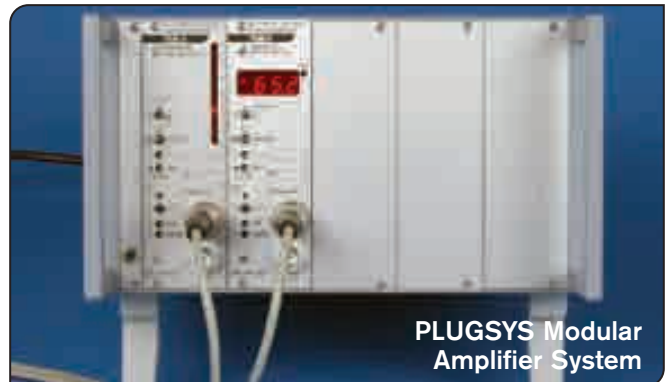
UP-100IH Core System, Advanced:
73-4386 (115V) or 73-4387 (230V) ●●●●●

Includes:

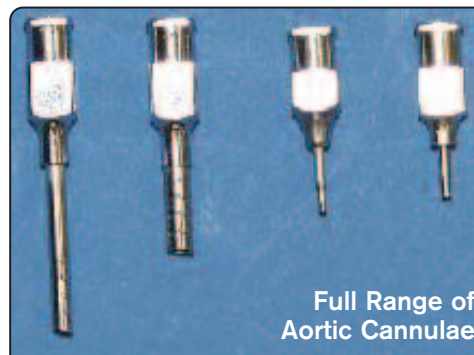
- UP-100 Base Unit
- Heart Chamber and Holder to UP-100 System
- UP-100 Addition for Langendorff (with cannulae for rat/guinea pig)
- Thermocirculator
- Analog Roller Pump
- Compliance Chamber (Windkessel)
- Perfusion Pressure Measurements
 - Pressure Transducer
 - TAM-D PLUGSYS Transducer Amplifier Module
- PLUGSYS Basic System Case (Core System 6 Slot Units)
 - UP-100IH Basic: PLUGSYS 601 Case, 10 Slot Units*
 - UP-100IH Advanced: PLUGSYS 603 Case, 20 Slot Units
- Left Ventricular Pressure Measurement
 - Pressure Transducer
 - TAM-A PLUGSYS Transducer Amplifier Module

** If your chosen options require more than 10 Slot Units you will need to choose the UP-100IH Advanced system.*

For a working unit, the core system requires the addition of a selection of one of the options UP-MOUSE or UP-RAT/GP.



PLUGSYS Modular Amplifier System



Full Range of Aortic Cannulae

UP-MOUSE 73-4388 ●●●●●

Additions to UP-100IH Core System for mouse hearts

Includes:

- Aortic Cannula with Luer Taper for Mice, OD 1.0 mm
- Pump Tubing (TYGON)
- Mini Balloon Kit for Mouse Heart
- Mouse Ventricular Balloon Assembly Kit
- 1 Liter Jacketed Buffer Reservoir and Tube Set

UP-RAT/GP 73-4389 ●●●●●

Additions to UP-100IH Core System for rat/guinea pig hearts

Includes:

- Pump Tubing (TYGON)
- 2 Liter Jacketed Buffer Reservoir and Tube Set
- Balloon Kit for rat/guinea pig hearts
 - 10 Balloons, Size 5 (0.1 ml Volume)
 - Spindle Syringe & Holder for Precise Adjustment of Preload Pressure
 - Stainless Steel Balloon Catheter with Ball-Mount

UP-100IH: Options

SCP 73-2806 ●●●●●

Constant Pressure/Flow Controller

Choose this option if you require the ability to perfuse a heart in constant pressure mode:

- Allows operation in constant pressure or constant flow with simple switch
- Additional measured signal/calculated parameters
 - Indirect Coronary Flow measurement
 - Calculation of Coronary Resistance

FEATURES & BENEFITS

- Accurate control of perfusion pressure or flow, even at very low flow rates
- Flexible perfusion circuit setup adjusts to suit individual perfusion conditions

Includes:

- SCP PLUGSYS Perfusion Controller Module
 - Utilizes 2 Slot Units



Fiber Oxygenator mounted to top plate of IH-SR



Fiber Oxygenator

UP-FLOW 73-4390 ●●●●●

Direct coronary flow measurement to UP-100IH for mouse, rat or guinea pig hearts

FEATURES & BENEFITS

- Ultrasonic transit time direct flow measurement – gold standard
- Unique integration of flow probe in perfusion path
- Laminar flow lines improve accuracy of flow measurement
- Thermal properties of Perspex adapter reduce temperature loss
- Increase system flexibility by allowing the study of Myogene Autoregulation (Reactive Hyperemia)
- Indirect flow measurement can typically follow increasing flow rates but often lags behind decreasing flow rates

Includes:

- 1.5 PRB Perivascular Flow Probe
- Flow Probe In-line Adapter & Mounting Block
- TTFM PLUGSYS Flowmeter
 - Utilizes 2 Slot Units
- Flow Probe Extension Cable



UP-FIBEROXY 73-4048 ●●●●●

Oxygenating System for foaming perfusates

Choose this option if you are using buffer supplemented with albumin, fatty acids, washed erythrocytes, or other foaming additive.

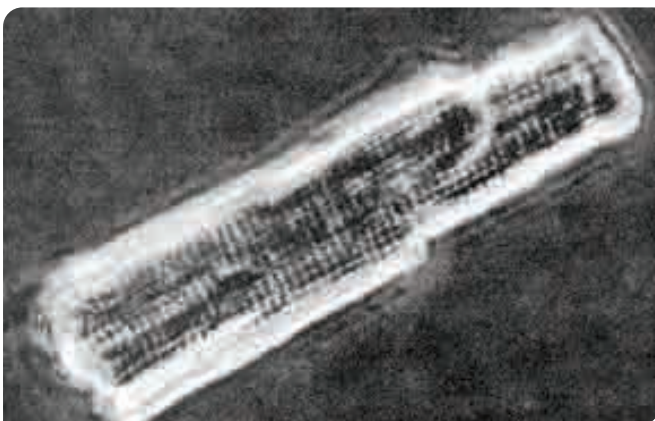
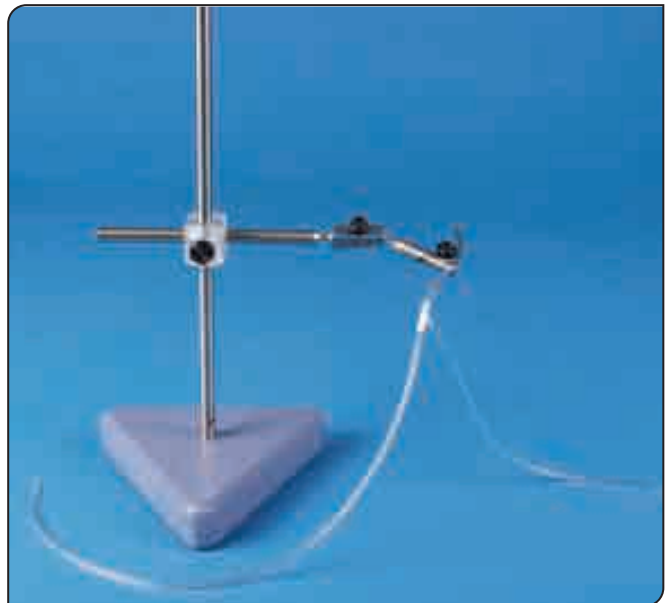
Features:

- MediSulfone Membrane Material
- 0.25 m² Oxygenating Surface Area
- 19 ml Priming Volume

Includes:

- Holder for Oxygenator
- Fiber Oxygenators, pkg. of 5
- Mounting and Connecting Kits for Oxygenator

UP-100IH: Options



UP-CELLISO 73-4392 (115V) or 73-4393 (230V) ●●●●●

Option for cardiomyocyte isolation on UP-100IH

Includes:

- Collagenase Reservoir (100 ml) with Cover
- Stopcocks, Tubing and Connectors
- Mini Magnetic Stirrer with Mini Stirbars, pkg. of 10

UP-PULM 73-4394 ●●●●●

Option for cannulating rat or guinea pig pulmonary artery for effluent sampling

- Use the cannulating system to collect effluent for your own analysis equipment

OR

- Add one of our Metabolic Monitoring Options for pH, pO_2 , and pCO_2 on pages 56-57
- Rat, guinea pig, and small rabbit only

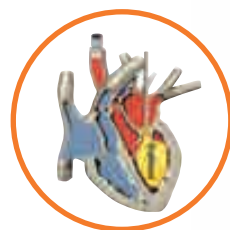
Includes:

- Pulmonary Artery Cannula Kit
- Bar and Ball Joint Holders to Mount Cannulating System
- Stand with Triangular Plate

UP-100IH References:

1. Bartosikova L, Necas J, Bartosik T, Frana P, Pavlik M. (2008). Changes in biomechanical parameters during heart perfusion and after midazolam pre-medication—experimental pilot study. *Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub.*, 152(1):79-82.
2. Carreira RS, Monteiro P, Kowaltowski AJ, Gonçalves LM, Providência LA. (2008). Nicorandil protects cardiac mitochondria against permeability transition induced by ischemia-reperfusion. *J Bioenerg Biomembr.*, 40(2):95-102.
3. Liehn EA, Tuchscheerer N, Kanzler I, Drechsler M, Fraemohs L, Schuh A, Koenen RR, Zander S, Soehnlein O, Hristov M, Grigorescu G, Urs AO, Leabu M, Bucur I, Merx MW, Zernecke A, Ehling J, Gremse F, Lammers T, Kiessling F, Bernhagen J, Schober A, Weber C. (2011). Double-Edged Role of the CXCL12/CXCR4 Axis in Experimental Myocardial Infarction. *Journal of the American College of Cardiology*, Volume 58(23), 2415-2423.
4. Matafome P, Monteiro P, Nunes E, Louro T, Amaral C, Moedas AR, Gonçalves L, Providência L, Seica R. (2008). Therapeutic association of atorvastatin and insulin in cardiac ischemia: study in a model of type 2 diabetes with hyperlipidemia. *Pharmacol Res.*, 58(3-4):208-14.
5. Monteiro P, Duarte AI, Moreno A, Gonçalves LM, Providência LA. (2003). Carvedilol improves energy production during acute global myocardial ischaemia. *Eur J Pharmacol*, 482(1-3):245-53.

IH-SR Langendorff: The Basis for Any Heart Perfusion Study



STARLING RESISTOR

- The IH-SR can be purchased as a working heart-ready upgradeable system by adding our Patented Membrane Flow Resistor instead of the SCP Perfusion Controller
- The Starling Resistor allows for a simple mechanical switch between Constant Flow and Constant Pressure Perfusion
- While pressure remains constant the flow will vary and will be directly measured by the built-in transit-time ultrasonic aortic flow probe



PERFUSATE SUPPLY & PERIPHERAL EQUIPMENT

- Unique Double-Walled Glass Reservoir with Aeration Pathway
- Roller Pump with Feedback Control
- Thermocirculator
- Electrical Stimulator for Pacing



AORTIC BLOCK

- Core of the System
- Very Low Flow Resistance
- Small Dead Space Volume
- Integrated Bubble Trap and Shut-Off Stopcock
- Highly Stable Attachment Point for the Heart, Probes and Electrodes
- Solid State Physiological Perfusion Circuit for Stable Pressure & Flow Control

PLUGSYS

- Modular Amplifier System
- Low Noise, Analog Fidelity and Control
- Huge Range of Measurement Capabilities
- Grows to Fit Your Application
- Compact, Space-Saving Arrangement
- Can Output Signals to Virtually Any Data Acquisition System

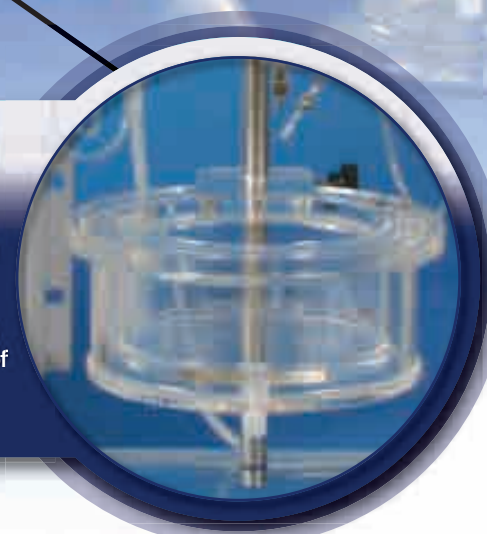


BASIC MEASURED PARAMETERS

- Perfusion Pressure
- Coronary Flow
- Isovolumetric LVP

HEART CHAMBER

- Closes Fully for Superior Temperature Control
- Spacious Enough for a Range of Physiological Measurement Probes and Electrodes
- Opens & Swings Completely Out of the Way for Easy Adjustment of Heart and Probes
- Removable for easy cleaning



BENEFITS:

- Compact Design, Optimized for: Mouse, Rat, Guinea Pig
- Constant Pressure or Constant Flow in One Unit
- Modular Design to Integrate More Applications in the Future
- Unique Aortic Block and Heart Chamber Allows Unsurpassed Physiological Simulation
- Small Flow Resistance and Low Dead Space Volume for Highly Reproducible and Accurate Results
- Low Volume Drug Injection Pathway is Ideal for Compound Screening
- A Complete, Flexible System for a Range of Applications

IH-SR BASIC: The Ultimate Choice for *Ex Vivo* Cardiovascular Research in Small Rodent Models



FEATURES & BENEFITS

- Compact design, optimized individually for: mouse, rat or guinea pig
- Constant pressure or constant flow perfusion in one unit, easily switch between the two modes
- Compact, doesn't require wall-installed high water columns, suitable for hearts from hypertensive rats (perfusion pressures up to 300 mmHg are possible)
- Unique integrated small volume Aortic Block with built-in bubble trap and windkessel
- Large fully-heated heart chamber
 - Natural physiological environment for the isolated heart
 - Hearts are kept alive for hours in a very stable physiologic environment
 - Easy-to-use with smooth open and closed operation
 - All electrodes, catheters and probes are fully enclosed for easy access and to maintain physiological conditions while performing the experiments.
- Unique cannula design
 - Cannula resistance is optimized according to Hagen-Poiseuilles physical law
 - Different cannula sizes available, all metal, no fragile glass cannulae
- Proprietary mini holders allow easy and stress-free positioning of electrodes, catheters and probes

IH-SR LANGENDORFF

The IH-SR Langendorff serves as the starting point for all isolated heart experiments. Advanced engineering provides ease-of-use and exceptional stability of measurements while maintaining the flexibility to upgrade to more advanced capabilities. Like our other Isolated Perfused Heart Systems, we do not use high water-columns to achieve a constant pressure head and rely on instead other safer methods (Starling Resistor or Feedback-based Perfusion Controller) that keep every portion of your system within easy reach.

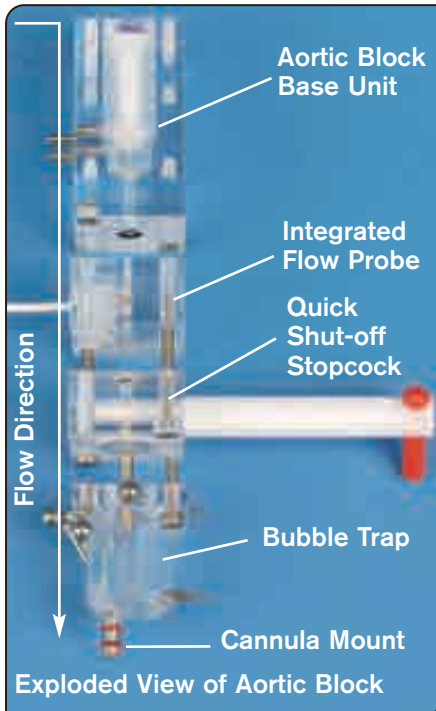
Because the Aortic Block is fully enclosed in the water-jacketed upper and lower IH-SR chamber and precision-milled from thermally stable Perspex, the temperature control of the IH-SR has the highest level of stability of all of the IH systems.

The IH-SR base system is capable of being expanded to a full ejecting Working Heart (Neely) system, accommodating aortic flows up to 60 ml/min. If you plan to upgrade to full working heart functionality after beginning with a Langendorff setup, it is recommended to acquire the Working Heart-Ready Langendorff system rather than the standard basic Langendorff as it will result in a cost-saving, simplified installation process with no duplication of functionality in the future.

If your studies require the isolation of Cardiomyocytes, the Cell Isolation Addition to the IH-SR provides a dedicated collagenase pathway that shares less than 2 ml of the system volume. If perfusate containing albumin or erythrocytes is used, aeration can be optimized with the addition of a fiber oxygenator. Options from ECG and MAP to pacing and metabolic monitoring of pH, pO₂, pCO₂ are available. Contact our expert technical team if you need assistance with system configuration, application support or custom design requests.

The complete system includes virtually everything you need to accomplish the basic Langendorff experiment, only requiring the addition of the appropriate species-specific package, the method of constant pressure perfusion and coronary flow measurement, and the desired data acquisition system. For detailed descriptions of all system extensions and options see pages 17-23, 53-60.

Aortic Block: The Single Most Important Part of System



Aortic Block with attached Cannula, LVP Balloon and Pacing Electrode



Full Range of Aortic Cannulae



AORTIC BLOCK

The Aortic Block really is the core of the IH-SR. It is the attachment point for the heart and the central hub for perfusion control, physiological monitoring and drug infusion. Over 20 years of experience, research and development have resulted in this system core which simply cannot be duplicated.

FEATURES & BENEFITS

- Unique integrated small-volume Aortic Block with built-in bubble trap and windkessel
- Bubble trap located just above the aortic cannula
- Built-in windkessel to simulate aortic compliance
- Low flow resistance and dead space volume, minimizes perfusion artifacts
- Integrated stopcock to control ischemia/reperfusion
- Small system volume, important if expensive drugs are used
- Drug injection pathway built directly into aortic perfusate stream

MEASURED SIGNALS AND CALCULATED PARAMETERS ON THE IH-SR BASIC SYSTEM:

The following signals are recorded as raw data:

- Isovolumetric Left Ventricular Pressure (Balloon Method)
- Aortic (Perfusion) Pressure
- Coronary Flow*

The following parameters are calculated from the raw data (using DAQ system):

- $dLVP/dt$, $dLVP/dt$ Max, $dLVP/dt$ Min, Contractility Index
- Systolic and Diastolic LVP
- Heart Rate
- Mean Perfusion Pressure
- Mean Perfusion Flow*
- Coronary Resistance*

* This Parameter is based on Indirect Flow Measurement with Option IH-SR-SCP or Direct Flow Measurement with IH-SR-STARLING and IH-SR-DIRECT added to the core system

The IH-SR Basic Consists of the Core System & Core Options

Langendorff only Configuration	Langendorff Working Heart-Ready Configuration ¹
Basic IH-SR Core System (choose one) <ul style="list-style-type: none"> 73-4344 (115V) 73-4343 (230V) 	<ul style="list-style-type: none"> Basic IH-SR Core System (choose one) 73-4344 (115V) 73-4343 (230V)
Species Specific Addition (choose one or both) <ul style="list-style-type: none"> 73-4019 IHSR-MOUSE 73-4020 IHSR-RGP 	Species Specific Addition (choose one or both) <ul style="list-style-type: none"> 73-4019 IHSR-MOUSE 73-4020 IHSR-RGP
SCP (Servo Pressure Controller) <ul style="list-style-type: none"> 73-2806 	STARLING-IHSR (Pressure Controller) <ul style="list-style-type: none"> 73-4346
	Direct Flow Measurement (choose one, see page 20) ² <ul style="list-style-type: none"> 73-4021 IHSR-FLOW-M 73-4022 IHSR-FLOW-RGP

¹ Upgrade from Langendorff to Working Heart is facilitated by purchasing this configuration

² If you work with both mouse and rat models, choose the IHSR-FLOW-RGP

IH-SR Core System, Basic: 73-4344 (115V) OR 73-4343 (230V) ●●●●●

Includes:

- IH-SR Base Unit for Small Rodent Hearts (for subjects up to 800 g)
- Thermocirculator
- Analog Roller Pump
- PLUGSYS Basic System Case 603
 - Core System Utilizes 4 of 20 total Slot Units
- Perfusion Pressure Measurements
 - Pressure Transducer
 - TAM-D PLUGSYS Transducer Amplifier Module
- Left Ventricular Pressure Measurement
 - Pressure Transducer
 - Holder for Pressure Transducer
 - TAM-A PLUGSYS Transducer Amplifier Module

* If your chosen options require more than 20 Slot Units you will need to choose the case expansion option (Option C-EX). See page 59.

For a working unit, the core system requires the addition of a selection of one of the perfusion pressure controller systems (SCP or STARLING-IHSR) and one of the options IHSR-MOUSE or IHSR-RAT/GP. The working heart ready configuration also requires the species-appropriate direct flow measurement option.

IHSR-MOUSE 73-4019 ●●●●●

Additions to IH-SR Core System for mouse hearts

Includes:

- Aortic Cannula for Mouse Hearts, 1.0 mm OD
- Pump Tubing (TYGON)
- Mini Balloon Kit for Mouse Heart
- Mouse Ventricular Balloon Assembly Kit
- 1 Liter Jacketed Buffer Reservoir and tube set

IHSR-RAT/GP 73-4020 ●●●●●

Additions to IH-SR Core System for rat/guinea pig hearts

Includes:

- Aortic Cannula for rat & guinea pig hearts
 - 2.3 mm OD
 - 3.0 mm OD
- Pump Tubing (TYGON)
- 2 Liter Jacketed Buffer Reservoir and Tube Set
- Balloon Kit for rat/guinea pig hearts
 - Stainless Steel LVP Balloon Catheter
 - 10 Size 5 Balloons (0.1 ml volume)
 - Spindle Syringe & Holder for Precise Adjustment of Preload Pressure

IH-SR BASIC: Core Options



SCP 73-2806 ●●●●●

Constant Pressure/Flow Controller

Choose this option if you require the ability to perfuse a heart in constant pressure mode:

- Allows operation in constant pressure or constant flow with simple switch
- Additional Measured Signal/Calculated Parameters
 - Indirect Coronary Flow measurement
 - Calculation of Coronary Resistance

FEATURES & BENEFITS

- Accurate control of perfusion pressure or flow, even at very low flow rates
- Flexible perfusion circuit setup adjusts to suit individual perfusion conditions

Includes:

- SCP PLUGSYS Perfusion Controller Module
 - Utilizes 2 Slot Units



STARLING-IHSR 73-4346 ●●●●●

Perfusion pressure control with Starling Resistor

Choose this option if you require constant pressure perfusion of the heart.

- Uses Teflon Membrane Flow Resistor, Manometer and Pressure Syringe to create a pressure-controlled valve in the aortic block
 - Flow rate is set high on the pump and only the flow that generates the set perfusion pressure is delivered to the heart while the remainder exits via the valve and returns to the reservoir
- Mechanical device that does not provide flow information and does not alter the pump flow rate
- Must choose direct coronary flow measurement to capture coronary flow data

Includes:

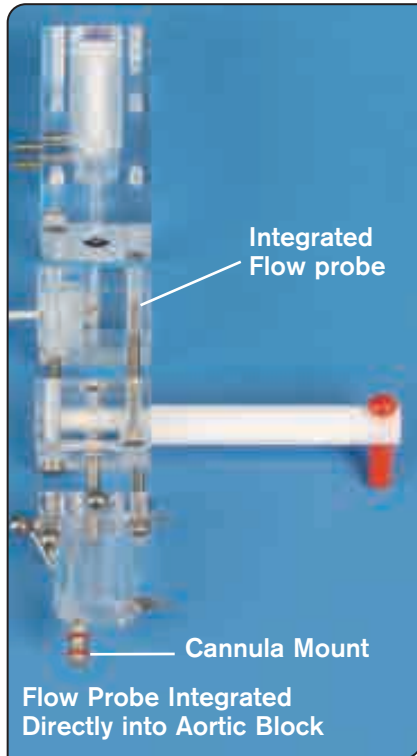
- Aortic Block Base Unit with Flange-Mounted Adjustable Flow Resistance
- Pressure Syringe with Mounting Bracket
- Manometer

NOTE

Planning to Upgrade to Working Heart?

See page 18 for Working Heart-Ready Langendorff configuration. ●●●●●

IH-SR Options: Direct Coronary Flow Measurement to IH-SR



FEATURES & BENEFITS

- Ultrasonic transit time direct flow measurement – gold standard
- Unique integration of flow probe in perfusion path
- Laminar flow lines improve accuracy of flow measurement
- Multiple flow probe sizes available, depending on species
- Compact design to reduce line resistance, minimize volume and reduce temperature loss
- Increase system flexibility by allowing the study of Myogene Autoregulation (Reactive Hyperemia)
- Indirect flow measurement can typically follow increasing flow rates but often lags behind decreasing flow rates
- Reduce time and costs for upgrading to working heart later

IHSR-FLOW-M 73-4021 ●●●●●

Direct flow for mouse heart

Includes:

- 1.0 PRB Perivascular Flow Probe
- In-line Flow Probe Adapter for IH-SR Aortic Block
- TTFM PLUGSYS Flowmeter
 - Utilizes 4 Slot Units
- Flow Probe Extension Cable

IHSR-FLOW-RGP 73-4022 ●●●●●

Direct flow for rat/guinea pig heart

Includes:

- 2.0 PSB Perivascular Flow Probe
- In-line Flow Probe Adapter for IH-SR Aortic Block
- TTFM PLUGSYS Flowmeter
 - Utilizes 4 Slot Units
- Flow Probe Extension Cable

IH-SR Options: Cell Isolation



Enzyme Solution Reservoir, 100 ml

**IHSR-CELLISO 73-4354 (115V)
or 73-3981 (230V)** ●●●●●

Option for cardiomyocyte isolation on IH-SR

Includes:

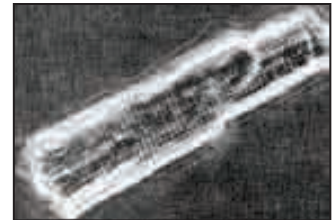
- Collagenase Reservoir (100 ml) with Cover
- Stopcocks, Tubing and Connectors
- Mini Magnetic Stirrer with Mini Stirbars (pkg. of 10)
- Heat Exchanger/Bubble Trap
- Effluete Funnel for Recirculation of Collagenase



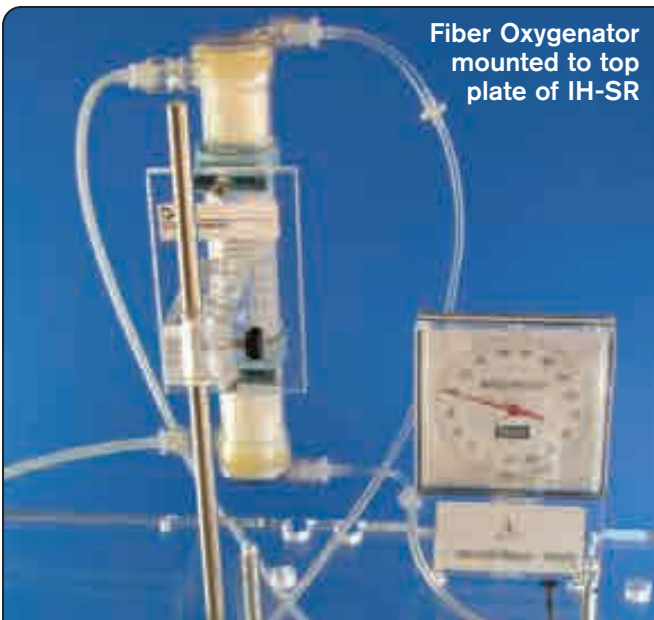
Mini Magnetic Stirrer with Reservoir



Cell Collection Funnel



Oxygenating System



Fiber Oxygenator
mounted to top
plate of IH-SR

IHSR-FIBEROXY 73-4449 ●●●●●

Oxygenating system for foaming solutions

Choose this option if you are using buffer supplemented with albumin, fatty acids, washed erythrocytes, or other foaming additive

FEATURES & BENEFITS

- MediSulfone membrane material
- 0.25 m² oxygenating surface areath
- Mounting and connecting kits for oxygenator

Includes:

- Holder for Oxygenator
- Fiber Oxygenators, pkg. of 5
- Mounting and Connecting Kits for Oxygenator

IH-SR Options: Pulmonary Cannulae and Preparation Dish



IHSR-PULM 73-4395 ●●●●●

Option for cannulating rat or guinea pig pulmonary artery for metabolic studies

- Use the cannulating system to collect effluent for your own analysis equipment

OR

- Add one of our Metabolic Monitoring Options for pH, PO_2 , and PCO_2 on pages 56-57
- Rat & guinea pig only - Cannot be used with mouse heart due to PA being too small (Use the mouse right ventricle cannulation option below for mouse metabolic studies)



IHSR-PULM-M 73-4396 ●●●●●

Option for cannulating mouse right ventricle for metabolic studies

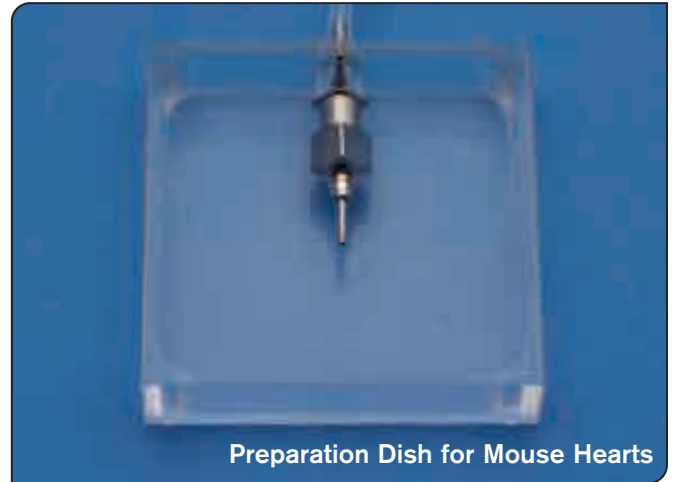
- Use the cannulating system to collect effluent for your own analysis equipment

OR

- Add one of our Metabolic Monitoring Options for pH, PO_2 , and PCO_2 on pages 56-57

Includes:

- Right Ventricle Cannulation Kit for mouse



Preparation Dish for Mouse Hearts

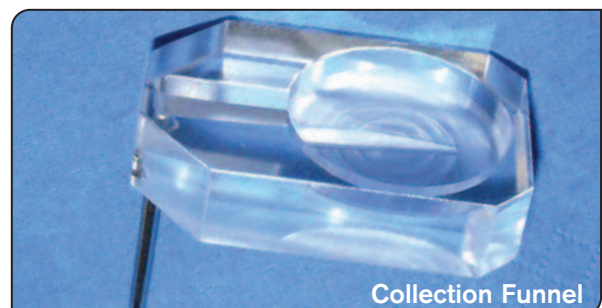
Preparation Dish for Mouse Hearts on IH-SR 73-0129 ●●●●●

Due to the small diameter of the aorta of the mouse heart, it can often be challenging to accomplish a quick cannulation. If the process takes too long, the heart becomes ischemically compromised and must be discarded or risk confounding any experimental data.

The Mouse Heart Preparation Dish is designed with a very thin base so that when placed on an ice bath the perfusate in the dish will be dramatically cooled resulting in cardioprotective hypothermia. The aortic cannula connector is designed to only accommodate the IH-SR mouse cannula. The mouse cannula is held stable in the dish while the heart is mounted. An inlet port on the dish serves as the attachment point for a syringe filled with cold buffer that is used to flush the blood from the heart. Overpressurizing the heart is prevented by a pressure relief port just prior to the aortic cannula.

Once the heart is secured onto the cannula with suture and flushed, it can be removed from the preparation dish and mounted onto the IH-SR Aortic Block.

Fraction Collection



Collection Funnel

IH-SR Working Heart-Ready Configuration

IH-SR Working Heart-Ready Configuration ●●●●●

For the researcher who knows that they will be upgrading to working heart in the future or would like to keep open the option for a quick upgrade, we recommend the Langendorff Working-Heart Ready configuration (page 18).

When it is time to upgrade to Working Heart you need only add:

■ IH-SR-WH Working Heart Option to IH-SR

• 73-4349 (115V)

• 73-4347 (230V)

■ Species Specific Addition

• IH-SR-WH-M 73-4033

• IH-SR-WH-RGP 73-4034

For full description of the Additions for Working Heart, see page 36-41 and 53-60.

IHSR-FRACTION 73-3329 ●●●●●

Effluate Funnel for fraction collection of pulmonary effluent dripping off of heart

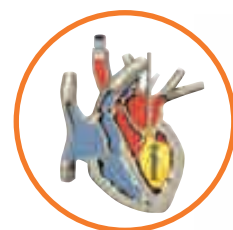
NOTE

For analysis of pH, PO₂ or PCO₂ the Pulmonary Artery Cannulation Kit IHSR-PULM should be used to collect effluate due to the influence of atmospheric O₂ and CO₂. ●●●●●

IH-SR Langendorff References:

- Andersen AD, Bentzen BH, Salling H, Klingberg H, Kanneworff M, Grunnet M, Pedersen SF, (2011). The cardioprotective effect of brief acidic reperfusion after ischemia in perfused rat hearts is not mimicked by inhibition of the Na(+)/H(+) exchanger NHE1. *Cell Physiol Biochem*, 28(1):13-24.
- Béguin PC, Joyeux-Faure M, Godin-Ribuot D, Lévy P, Ribaut C, (2005). Acute intermittent hypoxia improves rat myocardium tolerance to ischemia. *J Appl Physiol*, 99(3):1064-9.
- Clements RT, Feng J, Cordeiro B, Bianchi C, Sellke FW, (2011). p38 MAPK-dependent small HSP27 and α B-crystallin phosphorylation in regulation of myocardial function following cardioplegic arrest. *Am J Physiol Heart Circ Physiol*, 300(5), H1669-77.
- Clements RT, Cordeiro B, Feng J, Bianchi C, Sellke FW, (2011). Rottlerin increases cardiac contractile performance and coronary perfusion through BKCa++ channel activation after cold cardioplegic arrest in isolated hearts. *Circulation*, 124(11 Suppl):S55-61.
- da Rosa Araujo AS, Silva de Miranda MF, de Oliveira UO, Fernandes T, Llesuy S, Rios Kucharski LC, Khaper N, Belló-Klein A. (2010). Increased resistance to hydrogen peroxide-induced cardiac contracture is associated with decreased myocardial oxidative stress in hypothyroid rats. *Cell Biochem Funct*, 28(1):38-44.
- Fioretto JR, Querioz SS, Padovani CR, Matsubara LS, Okoshi K, Matsubara BB, (2002). Ventricular remodeling and diastolic myocardial dysfunction in rats submitted to protein-calorie malnutrition. *Am J Physiol Heart Circ Physiol*, 282(4):H1327-33.
- Georget M, Mateo P, Vandecasteele G, Lipskaia L, Defer N, Hanoune J, Hoerter J, Lugnier C, Fischmeister R, (2003). Cyclic AMP compartmentation due to increased cAMP-phosphodiesterase activity in transgenic mice with a cardiac-directed expression of the human adenylyl cyclase type 8 (AC8). *FASEB J*, 17(11):1380-91.
- Iwata K, Matsuno K, Nishinaka T, Persson C, Yabe-Nishimura C, (2006). Aldose reductase inhibitors improve myocardial reperfusion injury in mice by a dual mechanism. *J Pharmacol Sci*, 102(1):37-46.
- Joyeux M, Arnaud C, Godin-Ribuot D, Demenge P, Lamontagne D, Ribaut C, (2002). Endocannabinoids are implicated in the infarct size-reducing effect conferred by heat stress preconditioning in isolated rat hearts. *Cardiovasc Res*, 55(3):619-25.
- Joyeux-Faure M, Stanke-Labesque F, Lefebvre B, Béguin P, Godin-Ribuot D, Ribaut C, Launois SH, Bessard G, Lévy P, (2005). Chronic intermittent hypoxia increases infarction in the isolated rat heart. *J Appl Physiol*, 98(5):1691-6.
- Khabbaz KR, Feng J, Boodhwani M, Clements RT, Bianchi C, Sellke FW. (2008) Nonischemic myocardial acidosis adversely affects microvascular and myocardial function and triggers apoptosis during cardioplegia. *J Thorac Cardiovasc Surg*, 135(1):139-46.
- Løfgren B, Povlsen JA, Rasmussen LE, Støttrup NB, Solskov L, Krarup PM, Kristiansen SB, Bøtker HE, Nielsen TT, (2010). Amino acid transamination is crucial for ischaemic cardioprotection in normal and preconditioned isolated rat hearts—focus on L-glutamate. *Exp Physiol*, 95(1):140-52.
- Merx MW, Flögel U, Stumpe T, Gödecke A, Decking UK, Schrader J, (2001). Myoglobin facilitates oxygen diffusion. *FASEB J*, 15(6):1077-9.
- Merx MW, Schäfer C, Westenfeld R, Brandenburg V, Hidajat S, Weber C, Ketteler M, Jähnen-Dechent W, (2005). Myocardial stiffness, cardiac remodeling, and diastolic dysfunction in calcification-prone fetuin-A-deficient mice. *J Am Soc Nephrol*, 16(11):3357-64.
- Oh KS, Han W, Wang MH, Lee BH, (2007). The effects of chronic treatment with Morus bombycis KOIDZUMI in spontaneously hypertensive rats. *Biol Pharm Bull*, 30(7):1278-83.
- Pinto YM, Bader M, Pesquero JB, Tschöpe C, Scholtens E, van Gilst WH, Buikema H, (2000). Increased kallikrein expression protects against cardiac ischemia. *FASEB J*, 14(13):1861-3.

References Continued on page 78.



IH-5 Basic: The Preferred Electrophysiology & Safety

Choice for Cardiac Pharmacology



CONVENIENT ACCESS PORTS

- Drug Injection Pathway Built Directly in Aortic Perfusate Stream
- Integrated Stopcock Allows Switching Between a Primary and Secondary Perfusate (such as Cardioplegia Solution)
- Secondary Drug Injection Port or Probe Port for inserting Catheter-Type Probes (e.g. Temperature)



HEART CHAMBER & PLATFORM

- Large Chamber for Accommodating a Range of Physiological Probes and Electrodes
- Knob Conveniently Raises and Lowers Elevator Platform
- Fully Surrounds Heart & Lower Aortic Block for Temperature Stability



PLUGSYS

- Modular Amplifier System
- Low Noise, Analog Fidelity and Control
- Compact, Space-Saving Arrangement
- Output Signals to Virtually Any Data Acquisition System
- Largest Range of Measurement Capabilities with Optional Case Expansion



WORKING HEART READY

- Equip the Langendorff Core System with Direct Flow Measurement and the Starling Constant Pressure Control Option to Make your System Working Heart Ready for Later Upgrade

BASIC MEASURED PARAMETERS

- Perfusion (Aortic) Pressure
- Coronary Flow
- Isovolumetric LVP

AORTIC BLOCK

- Core of the System
- Low Flow Resistance: Engineered for Increased Flow up to 500 ml/min
- Unique Small Volume Aortic Block with Built-In Bubble Trap & Windkessel
 - Reproduces *In Situ* Elastic Properties of the Aorta
 - Adjustable Air Volume in Windkessel for Optimal Pulsation Dampening
- Solid State Perfusion Technology Mimics *In Vivo* Perfusion and Prevents Measurement Artifact
- Highly Stable Attachment Point for the Heart, Probes & Electrodes
- Unique Proprietary Aortic Cannulae
 - Multiple Sizes Available (2 – 6 mm OD)
 - Suture Rings Allow No-Slip Heart Mounting
 - Rugged Stainless Steel – No Fragile Glass



FEATURES:

- Suitable for Hearts from Hypertensive Animals with Perfusion Pressures up to 300 mmHg
- Compact System, No High Wall-Installed Water Columns
- Constant Pressure and Constant Flow Perfusion in One Unit
- Modular System is Fully Upgradeable/Expandable at any Time
- Large 6 L Perfusate Reservoir Accommodates Enough Perfusate for Rabbit Langendorff and Working Heart Requirements (2 L Available for smaller species)

ELECTROPHYSIOLOGY & SAFETY PHARMACOLOGY

- Single or Multi-Lead ECG Analysis (up to 12)
- ECG Mapping
- Epicardial Monophasic Action Potentials (up to 8)
- Endocardial Monophasic Action Potential



IH-5 BASIC: The Preferred Choice for Cardiac Electrophysiology & Safety Pharmacology



FEATURES & BENEFITS

- Compact design, optimized individually for: rabbit, rat or guinea pig
- Constant pressure or constant flow perfusion in one unit, easily switch between the two modes
- Compact, doesn't require wall installed high water columns, suitable for hearts from hypertensive animals (perfusion pressures up to 300 mmHg are possible)
- Unique integrated small volume aortic block with built-in bubble trap and compliance chamber
- Unique cannulae design
 - Cannula resistance is optimized according to Hagen-Poiseuilles Physical Law
 - Different cannula sizes available, all metal, no fragile glass cannulae
- Proprietary mini holders allow easy and stress-free access to hold electrodes and catheters in position
- Drug injection pathway built directly into aortic perfusate stream
- Easily upgraded to a Working Heart System

IH-5 LANGENDORFF

The IH-5 utilizes the architecture of the ground-breaking IH-SR to set the standard for isolated heart perfusion in rabbits, adult guinea pigs, or adult rats. Engineered for the increased flow produced by these species (up to 500 mL/min), the IH-5 offers ultimate perfusion stability and real physiological conditions for longer, more relevant recordings with fewer artifacts. This compact platform has been

optimized to create *in situ*-like perfusion features, delivering a considerably higher sensitivity for various experimental manipulation while maintaining the advantages of an *ex vivo* preparation.

The modular nature of the IH-5 allows the system to evolve along with your research. A Langendorff system can easily be upgraded to full Working Heart (according to Neely); and any IH-5 can be upgraded with a range of measurement capabilities unmatched by any system, like multi-channel ECG and MAP for a complete cardiac electrophysiology workstation.

Other useful add-ons include drug addition (using a syringe pump) and pacing. If perfusate containing albumin or erythrocytes is used, the oxygenation can be optimized with the addition of a fiber oxygenator. The IH-5 utilizes convenient switches that allow the researcher to easily change from constant flow to constant pressure perfusion, Langendorff to Working Heart, and between 2 different perfusion solutions.

The complete system includes virtually everything you need to accomplish the basic Langendorff experiment, only requiring the addition of the appropriate species-specific package, the method of constant pressure perfusion and coronary flow measurement, and the desired data acquisition system. For detailed descriptions of all system extensions and options see pages 27-35, 53-60. Contact our expert technical team if you need assistance with system configuration, application support or custom design requests.

MEASURED SIGNALS & PARAMETERS ON AN IH-5 BASIC SYSTEM:

The following signals are recorded as raw data:

- Isovolumetric Left Ventricular Pressure (Balloon Method)
- Aortic (Perfusion) Pressure
- Coronary Flow*

The following parameters are calculated from the raw data (using a DAQ System):

- dLVP/dt, dLVP/dt Max, dLVP/dt Min, Contractility Index
- Systolic and Diastolic LVP
- Heart Rate
- Mean Perfusion Pressure
- Mean Perfusion Flow*
- Coronary Resistance*

* This Parameter is based on Indirect Flow Measurement with Option SCP or Direct Flow Measurement with IH5-STARLING and IH5-DIRECT added to the core system.

IH-5 BASIC: Core System & Core Options

Langendorff only Configuration	Langendorff Working Heart-Ready Configuration ¹
Basic IH-5 Core System (choose one) <ul style="list-style-type: none"> 73-4397 (115V) 73-4398 (230V) 	<ul style="list-style-type: none"> Basic IH-5 Core System (choose one) 73-4397 (115V) 73-4398 (230V)
SCP (Servo Pressure Controller) <ul style="list-style-type: none"> 73-2806 	STARLING-IH5 (Pressure Controller) <ul style="list-style-type: none"> 73-4435
Species Specific Addition (choose one or both) <ul style="list-style-type: none"> 73-4399 IH5-RGP 73-4400 IH5-RAB 	Species Specific Addition (choose one or both) <ul style="list-style-type: none"> 73-4399 IH5-RGP 73-4435 IH5-RAB
Heart Chamber (choose one) <ul style="list-style-type: none"> 73-4401 IH5-HC-CARDIO 73-4402 IH5-HC-EPHYS 	Heart Chamber (choose one) <ul style="list-style-type: none"> 73-4401 IH5-HC-CARDIO 73-4402 IH5-HC-EPHYS
	Direct Flow Measurement (Aortic Flow in WH) (choose one) <ul style="list-style-type: none"> 73-4403 IH5-FLOW-RGP 73-4404 IH5-FLOW-RAB

¹Upgrade from Langendorff to Working Heart is facilitated by purchasing this configuration

IH-5 Core System, Basic: 73-4397 (115V) OR 73-4398 (230V) ●●●●●

Includes:

- IH-5 Base Unit for large rodent hearts (from subjects up to 2.5 kg)
- Thermocirculator
- Analog Roller Pump
- PLUGSYS Basic System Case 603
 - Core System Utilizes 4 of 20 total Slot Units
- Perfusion Pressure Measurements
 - Pressure Transducer
 - TAM-D PLUGSYS Transducer Amplifier Module
- Left Ventricular Pressure Measurement
 - Pressure Transducer
 - Holder for Pressure Transducer
 - TAM-A PLUGSYS Transducer Amplifier Module

* If your chosen options require more than 20 Slot Units you will need to choose the case expansion option (Option C-EX). See page 59.

For a working unit, the core system requires the addition of a selection of one of the perfusion pressure controller systems (SCP or STARLING-IH5), one of the options IH5-RGP or IH5-RAB, and a heart chamber (IH5-CARDIAC or IH5-EPHYS). The working heart-ready configuration also requires the species-appropriate aortic/direct flow measurement option.



IH5-RGP 73-4399 ●●●●●

Additions to IH-5 Core System for rat/guinea pig hearts

Includes:

- Aortic Cannula Set
 - 2.5 mm OD
 - 3.0 mm OD
- System Tubing for rat/guinea pig
- Balloon Kit for rat/guinea pig hearts on IH-5
 - 10 Balloons, Size 5 (0.1 mL volume)
 - Spindle Syringe & Holder for Precise Adjustment of Preload Pressure
- 2 Liter Jacketed Buffer Reservoir & Tube Set

IH-5 BASIC: Core Options



IH5-RAB 73-4400 ●●●●●

Additions to IH-5 Core System for rabbit hearts

Includes:

- Aortic cannula for rabbit hearts
 - 3.0 mm OD
 - 4.0 mm OD
 - 5.0 mm OD
- System Tubing for rabbit
- 6 Liter Jacketed Buffer Reservoir with Tubing
- Balloon Kit for rabbit hearts
 - 5 Size 12 Balloons (1.3 mL volume)
 - 5 Size 13 Balloons (1.6 mL volume)
 - Spindle Syringe & Holder for Precise Adjustment of Preload Pressure



SCP 73-2806 ●●●●●

Constant Pressure/Flow Controller

Choose this option if you require the ability to perfuse a heart in constant pressure mode:

- Allows operation in constant pressure or constant flow with simple switch
- Additional Measured Signal/Calculated Parameters (with DAQ)
 - Indirect Coronary Flow measurement
 - Calculation of Coronary Resistance

FEATURES & BENEFITS

- Accurate control of perfusion pressure or flow, even at very low flow rates
- Flexible perfusion circuit setup adjusts to suit individual perfusion conditions

Includes:

- SCP PLUGSYS Perfusion Controller Module
 - Utilizes 2 Slot Units

NOTE

Planning to Upgrade to Working Heart?

See page 27 for Working Heart-Ready Langendorff configuration. ●●●●●

IH-5 BASIC: Core Options



STARLING-IH5 73-4435 ●●●●●

Perfusion pressure control with Starling Resistor

Choose this option if you require constant pressure perfusion of the heart:

- Uses Teflon Membrane Flow Resistor, Manometer and Pressure Syringe to create a pressure-controlled valve in the aortic block
- Mechanical device that does not provide flow information and does not alter the pump flow rate
 - Flow rate is set high on the pump and only the flow that generates the set perfusion pressure is delivered to the heart while the remainder exits via the valve and returns to the reservoir
- Must choose Direct Coronary Flow measurement to capture Coronary Flow data

Includes:

- Aortic Block Base Unit with Flange-Mounted Adjustable Flow Resistance
- Pressure Syringe with Mounting Bracket
- Manometer



IH-5 LVP Balloon Catheter Kit



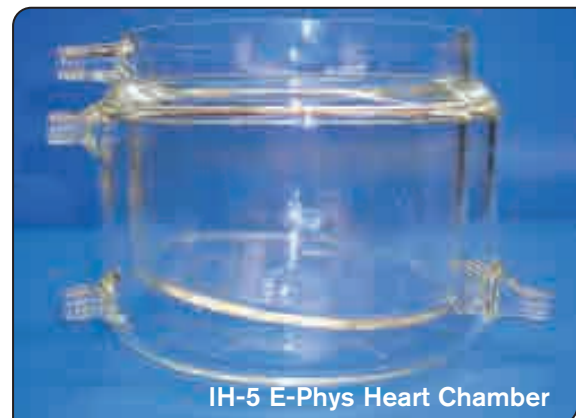
IH-5 Heart Chamber

IH5-HC-CARDIO 73-4401 ●●●●●

Heart chamber for IH-5 Core System for cardiovascular studies

Includes:

- Standard IH-5 Heart Chamber (ID 100 mm, Inside Depth 100 mm, Immersion Height 85 mm, Volume 0.65 L)
- IH-5 LVP Balloon Catheter Kit for rat, guinea pig, & rabbit)



IH-5 E-Phys Heart Chamber



IH5-HC-EPHYS 73-4402 ●●●●●

Choose this option if the multi-ECG ring and/or circular MAP ring will be used

Includes:

- IH-5 Heart Chamber for Electrophysiology (ID 145 mm, Inside Depth 100 mm, Immersion Height 85 mm, Volume 1.44 L, Sloping bottom with Bottom Drain)
- IH-5 LVP Balloon Catheter Kit, Special Version, for rat, guinea pig, & rabbit

See pages 32-35 for all available Multi-ECG and MAP Electrophysiology Options to the IH-5.

IH-5 Options: Direct Coronary Flow Measurement and Oxygenation



FEATURES & BENEFITS

- Ultrasonic transit time direct flow measurement – gold standard
- Unique integration of flow probe in perfusion path
- Laminar flow lines improve accuracy of flow measurement
- Multiple flow probe sizes available, depending on species
- Compact design to reduce line resistance, minimize volume and reduce temperature loss
- Increase system flexibility by allowing the study of Myogene Autoregulation (Reactive Hyperemia)
- Indirect flow measurement can typically follow increasing flow rates but often lags behind decreasing flow rates
- Reduce time and costs for upgrading to working heart later

IH5-FLOW-RGP 73-4403 ●●●●●

Direct coronary flow for rat, guinea pig and rabbit heart (Aortic flow in rat/guinea pig Working Heart)

Includes:

- 2.5 PSB Perivascular Flow Probe
- In-line Flow Probe Adapter for IH-5 Aortic Block
- TTFM PLUGSYS Flowmeter
 - Utilizes 4 Slot Units

IH5-FLOW-RAB 73-4404 ●●●●●

Aortic flow for rabbit heart

Includes:

- 4.0 PSB Perivascular Flow Probe
- In-line Flow Probe Adapter for IH-SR Aortic Block
- TTFM PLUGSYS Flowmeter
 - Utilizes 4 Slot Units



IH5-FIBEROXY 73-4348 ●●●●●

Oxygenating System for foaming perfusates

Choose this option if you are using buffer supplemented with albumin, fatty acids, washed erythrocytes, or other foaming additive

FEATURES & BENEFITS

- MediSulfone membrane material
- 0.6 m² oxygenating surface area
- 54 ml priming volume

Includes:

- Holder for Oxygenator
- Fiber Oxygenators, pkg. of 5
- Mounting and Connecting Kits for Oxygenator

IH-5 Options: Effluent Collection for Metabolic Analysis



IH5-PULM-RGP 73-0206 ●●●●●

Option for cannulating rat or guinea pig pulmonary artery for metabolic studies

- Use the cannulating system to collect effluent for your own analysis equipment

OR

- Add one of our Metabolic Monitoring Options for pH, pO_2 , and pCO_2 on pages 56 and 57

Includes:

- Pulmonary Artery Cannula Kit, 2.5 mm OD

IH5-PULM-RAB 73-0517 ●●●●●

Option for cannulating rabbit pulmonary artery for metabolic studies

- Use the cannulating system to collect effluent for your own analysis equipment

OR

- Add one of our Metabolic Monitoring Options for pH, pO_2 , and pCO_2 on pages 56 and 57

Includes:

- Large Pulmonary Artery Cannula Kit, 4.0 mm OD

Working Heart-Ready Langendorff Configuration

Working Heart-Ready Langendorff Configuration ●●●●●

For the researcher who knows that they will be upgrading to working heart in the future or would like to keep open the option for a quick upgrade, we recommend the Langendorff Working-Heart Ready Configuration (page 27).

When it is time to upgrade to Working Heart you need only add:

- IH5-WH Working Heart Option to IH-5
 - 73-4411 (115V)
 - 73-4412 (230V)
- Species Specific Addition
 - IH5-WH-RGP 73-4413
 - IHSR-WH-RAB 73-4414

For full description of the Additions for Working Heart, see page 42-46, 53-60.

The IH-5 Electrophysiology Workstation



IH-5 ELECTROPHYSIOLOGY WORKSTATION

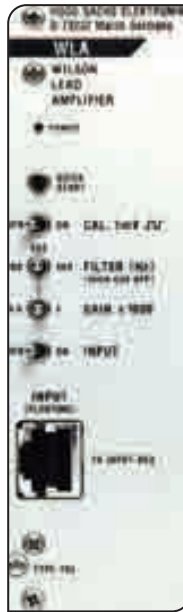
The following options allow for transformation of the IH-5 Isolated Heart System into a full Cardiac Electrophysiology Workstation. This is the most widely used system for researchers who are interested in cardiac mapping, dispersion of ventricular repolarization, arrhythmias, characterization of regional ischemias using MAP, activation time, and similar applications. This series of system configurations is particularly suited for safety pharmacology laboratories.

Simply choose a combination of the following ECG and MAP options that suits your application and then choose the designated Input Box Option.

For single lead ECG, epicardial MAP, and endocardial MAP go to pages 53-55.



The IH-5 Electrophysiology Workstation (continued)



IH5-6LEAD 73-4405 ●●●●●

6 Lead Einthoven-Goldberger ECG

Includes:

- 6-Lead ECG Electrode Insert
- PLUGSYS EGM Einthoven Goldberger Module
 - Utilizes 2 Slot Units
- BNC Output Module

NOTE This option requires 6 available data acquisition input channels. ●●●●●

IH5-12LEAD 73-4406 ●●●●●

6 Lead Einthoven-Goldberger ECG and 6 Wilson leads

Includes:

- 12-Lead ECG Electrode Insert
- PLUGSYS EGM Einthoven Goldberger Module
 - Utilizes 2 Slot Units
- PLUGSYS WLA Wilson Lead Amplifier Module
 - Utilizes 2 Slot Units
- BNC Output Module x 2

NOTE This option requires 12 available data acquisition input channels. ●●●●●

The IH-5 Electrophysiology Workstation (continued)

IH5-MAP6 73-4407 ●●●●●

Multi-MAP addition for 6 MAP

Includes:

- 6 MAP Electrodes
- PLUGSYS MAPM6 Monophasic Action Potential Module
 - Utilizes 3 Slot Units
- BNC Output Module

NOTE

This option requires 6 available data acquisition input channels and requires one of the input box options below. ●●●●●

IH5-MAP3 73-4408 ●●●●●

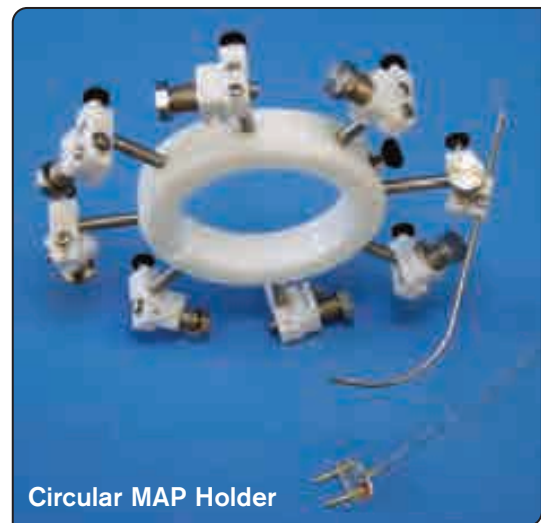
Multi-MAP addition for 3 MAP

Includes:

- 3 MAP Electrodes
- PLUGSYS MAPM3 Monophasic Action Potential Module
 - Utilizes 2 Slot Units
- BNC Output Module

NOTE

This option requires 3 available data acquisition input channels and requires one of the input box options below. ●●●●●



Circular MAP Holder

Option	Input Box Description	Compatible Configurations
73-1789	Up to 12 ECG (No MAP)	IH5-6LEAD or IH5-12LEAD
73-4438	Up to 6 MAP*	IH5-MAP3 or IH5-MAP6
73-4439	Up to 12 MAP*	IH5-MAP3 and IH5-MAP6
73-4440	Up to 12 ECG, Up to 6 MAP*	IH5-12LEAD and IH5-MAP6
73-4441	Up to 12 ECG, Up to 12 MAP*	IH5-12LEAD and IH5-MAP6 and IH5-MAP3

*These options include the circular MAP holder for mounting on the IH-5 Basic System



The IH-5 Electrophysiology Workstation (continued)

IH5-BUS32 73-4409 ●●●●●

32 channel bus expansion for PLUGSYS housing 603

Includes:

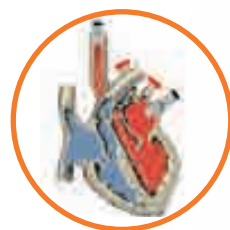
- PLUGSYS Analog Bus Splitter
- ROM-B PLUGSYS 8-Fold BNC Output, Ch 1-8
- ROM-B PLUGSYS 8-Fold BNC Output, Ch 9-16

IH-5 Langendorff References:

1. Bentzen BH, Bahrke S, Wu K, Larsen AP, Odening KE, Franke G, vaňs Gravesande KS, Biermann J, Peng X, Koren G, Zehender M, Bode C, Grunnet M, Brunner M, (2011). Pharmacological activation of Kv11.1 in transgenic long QT-1 rabbits. *J Cardiovasc Pharmacol*, 57(2):223-30.
2. Biermann J, Wu K, Odening KE, Asbach S, Koren G, Peng X, Zehender M, Bode C, Brunner M, (2011). Nicorandil normalizes prolonged repolarisation in the first transgenic rabbit model with Long-QT syndrome 1 both in vitro and in vivo. *Eur J Pharmacol.*, 650(1):309-16.
3. Ebel D, Schlack W, Comfère T, Preckel B, Thämer V, (1999). Effect of propofol on reperfusion injury after regional ischaemia in the isolated rat heart. *Br J Anaesth.*, 83(6):903-8.
4. Eckardt L, Breithardt G, Haverkamp W, (2002). Electrophysiologic characterization of the antipsychotic drug sertindole in a rabbit heart model of torsade de pointes: low torsadogenic potential despite QT prolongation. *J Pharmacol Exp Ther*, 300(1):64-71.
5. Favory R, Lancel S, Tissier S, Mathieu D, Decoster B, Nevière R, (2006). Myocardial dysfunction and potential cardiac hypoxia in rats induced by carbon monoxide inhalation. *Am J Respir Crit Care Med*, 174(3):320-5.
6. Guo L, Dong Z, Guthrie H, (2009). Validation of Guinea pig Langendorff heart model for assessing potential cardiovascular liability of drug candidates. *J Pharmacol Toxicol Methods.*, 60(2):130-51.
7. Hansen RS, Olesen SP, Grunnet M, (2007). Pharmacological activation of rapid delayed rectifier potassium current suppresses bradycardia-induced triggered activity in the isolated guinea pig heart. *J Pharmacol Exp Ther.*, 321(3):996-1002.
8. Kim HD, (2003). Infarct size-limiting effect of calcium preconditioning in rabbit hearts. *J Korean Med Sci.*, 18(3):337-43.
9. Kim H, Kim DJ, Chung HS, Shim SJ, Yoo UH, Rah BJ, Kim HD, (1998). Evidence of protein kinase C translocation by ischemic preconditioning in global ischemia model. *J Korean Med Sci.*, 13(5):473-82.
10. Kjelbye AL, Holstein-Rathlou NH, Petersen JS., (2002). Anti-arrhythmic peptide N-3-(4-hydroxyphenyl)propionyl Pro-Hyp-Gly-Ala-Gly-OH reduces dispersion of action potential duration during ischemia/reperfusion in rabbit hearts. *J Cardiovasc Pharmacol.*, 40(5):770-9.
11. Laursen M, Grunnet M, Olesen SP, Jespersen T, Mow T, (2011). Keeping the rhythm – pro-arrhythmic investigations in isolated Göttingen minipig hearts. *J Pharmacol Toxicol Methods.*, 64(2):134-44.
12. Laursen M, Olesen SP, Grunnet M, Mow T, Jespersen T, (2011). Characterization of cardiac repolarization in the Göttingen minipig. *J Pharmacol Toxicol Methods.*, 63(2):186-95.
13. Milberg P, Eckardt L, Bruns HJ, Biertz J, Ramtin S, Reinsch N, Fleischer D, Kirchhof P, Fabritz L, Breithardt G, Haverkamp W. (2002). Divergent proarrhythmic potential of macrolide antibiotics despite similar QT prolongation: fast phase 3 repolarization prevents early afterdepolarizations and torsade de pointes. *J Pharmacol Exp Ther.*, 303(1):218-25.
14. Milberg P, Pott C, Fink M, Frommeyer G, Matsuda T, Baba A, Osada N, Breithardt G, Noble D, Eckardt L, (2008). Inhibition of the Na⁺/Ca²⁺ exchanger suppresses torsades de pointes in an intact heart model of long QT syndrome-2 and long QT syndrome-3. *Heart Rhythm.*, 5(10):1444-52.
15. Milberg P, Reinsch N, Osada N, Wasmer K, Mönnig G, Stypmann J, Breithardt G, Haverkamp W, Eckardt L, (2005). Verapamil prevents torsade de pointes by reduction of transmural dispersion of repolarization and suppression of early afterdepolarizations in an intact heart model of LQT3. *Basic Res Cardiol*, 100(4):365-71.
16. Milberg P, Reinsch N, Wasmer K, Mönnig G, Stypmann J, Osada N, Breithardt G, Haverkamp W, Eckardt L, (2005). Transmural dispersion of repolarization as a key factor of arrhythmogenicity in a novel intact heart model of LQT3. *Cardiovasc Res*, 65(2):397-404.

IH-SR Working Heart: The for Physiological

Fully-Ejecting Working Heart Model Cardiovascular Studies



BENEFITS

- Assessment of External Heart Work Under Adjustable Load
- Optional Continuous Measurement of Metabolic Parameters, i.e. pH, pO₂, pCO₂
- Compact Design, Optimized for Each Species: Mouse, Rat, Guinea Pig
- Modular Design to Integrate More Applications in the Future
- Unsurpassed Physiological Environment
- Unique Aortic Block for Precision Preload and Afterload Control
- Small Flow Resistance and Low Dead Space Volume for Highly Reproducible and Accurate Results
- Low Volume Drug Injection Pathway
- Solid State Physiological Perfusion Circuit Mimics In-vivo Perfusion and Prevents Measurement Artifact

LEFT ATRIAL BLOCK

- Integrated Constant Pressure Preload Column
- Low Flow Resistance for Optimal Atrial Fill
- Built in Shut Off Stopcock for Rapid Control of Ventricular Flow
- Integrated Flow and Pressure Measurement

FLOW MEASUREMENT

- Integrated Constant Pressure Preload Column
- Low Flow Resistance for Optimal Atrial Fill
- Built in Shut Off Stopcock for Rapid Control of Ventricular Flow
- Integrated Flow and Pressure Measurement

PLUGSYS

- Modular System Allows Easy Upgrade of Functionality from Langendorff to Working Heart
- Expands to a Second PLUGSYS Case to Accommodate All Upgrades and Additions

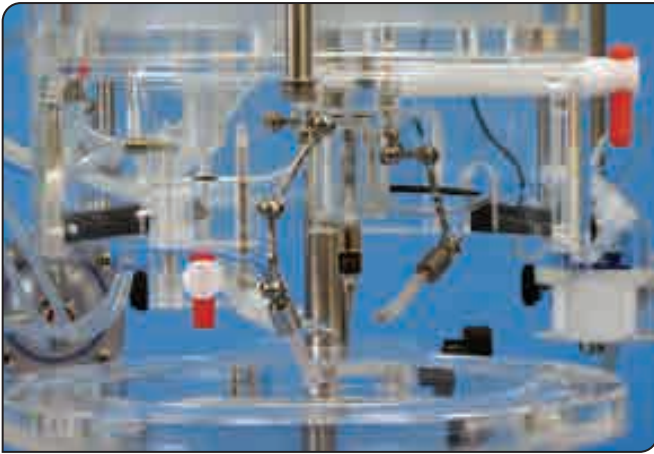
PHYSIOLOGICAL STARLING RESISTANCE

- Patented Membrane Afterload Control
- 0-300mmHg Adjustment Range
- Allows Precise Control of Cardiac Afterload to Simulate Hypo, Normo, or Hypertensive States

AORTIC BLOCK

- Unique Physiological Afterload System (Starling Resistor)
- Natural Physiological Environment
- Low Flow Resistance and Dead Space Volume
- Built-in Windkessel to Simulate Aortic Compliance
- Integrated Pathway for Insertion of a Pressure or Pressure-Volume Catheter

IH-SR Working Heart



FEATURES & BENEFITS

- Allows rapid and easy switching between Working Heart and Langendorff Modes
- Patented physiological afterload system (Starling Resistor) eliminates the conventional water column to create an afterload. The result is vastly improved arterial pressure evaluation without the risk of damage to heart valves
- Integrated low volume afterload-optimized aortic block
- Compact, less space in lab is necessary, no high water column afterload (afterload pressures up to 300 mmHg are possible)
- Reduced line resistance, optimized to exceed species flow producing optimal atrial filling
- Proprietary patented afterload system to eliminate water column bouncing
- Laminar flow lines to improve accuracy of flow measurement
- Design optimized to minimize volume and reduce temperature losses
- Provides a valuable tool for the researcher who wants to study cardiac function and metabolism
- Combines the advantages of an isolated organ preparation with *in situ*-like perfusion features
- Allows a more comprehensive monitoring of functional parameters, the calculation of the external heart work and mechanical efficiency, and a considerably higher sensitivity for various experimental manipulations

MEASURED SIGNALS AND CALCULATED PARAMETERS ON AN IH-SR WORKING HEART SYSTEM:

All parameters of standard Langendorff plus the following signals can be recorded:

- Preload (left atrial preload / ventricular filling pressure)
- Afterload (determining the diastolic and systolic aortic pressure)
- Left Ventricular Pressure or Pressure-Volume Loops
- Atrial, Aortic and Coronary Flow

IHSR-WH 73-4349 (115V) or 73-4347 (230V) ●●●●●

Working Heart option to IH-SR Core System

The Working Heart option must be paired with the system configuration detailed in the chart on page 18 "Langendorff Working Heart-Ready Configuration." If you are upgrading from a Working Heart-Ready configuration or are building a Working Heart System from scratch, then simply add the Working Heart Option and one or both of the species-specific options below.

Includes:

- Left Atrial Cannulating System
 - Preload Reservoir (2-7 ml capacity), continuously refilled with fresh solution
 - Movable Atrium Connection Adapter
 - Holder for Preload Pressure Transducer
- Peristaltic Pump with Tubing
- Preload Pressure Measurement
 - Venous Pressure Transducer
 - TAM-A Amplifier
 - Utilizes 2 Slot Units

IHSR-WH-M 73-4033 ●●●●●

Working Heart left atrial cannula for mouse heart, 1.3 mm OD

IHSR-WH-RGP 73-4034 ●●●●●

Working Heart left atrial cannula for rat and guinea pig Heart, 2.3 mm OD

If you are upgrading from a basic Langendorff system ("Langendorff only Configuration") as detailed in the chart on page 18) please contact our technical team for assistance.

IH-SR Working Heart Options: Cardiac Output Measurement



FEATURES & BENEFITS

- Ultrasonic transit time direct flow measurement – gold standard
- Unique integration of flow probe in atrial perfusion path
- Laminar flow lines improve accuracy of flow measurement
- Multiple flow probe sizes available, depending on species
- Compact design to reduce line resistance, minimize volume and reduce temperature loss

IHSR-CO-M 73-4035 ●●●●●

Cardiac output for mouse heart

Includes:

- 1.0 PRB Perivascular Flow Probe
- In-line Flow Probe Adapter for IH-SR Atrial Block
- TTFM PLUGSYS Flowmeter
 - Utilizes 4 Slot Units
- Flow Probe Extension Cable

IHSR-CO-RGP 73-4036 ●●●●●

Cardiac output for rat/guinea pig heart

Includes:

- 2.5 PSB Perivascular Flow Probe
- In-line Flow Probe Adapter for IH-SR Atrial Block
- TTFM PLUGSYS Flowmeter
 - Utilizes 4 Slot Units
- Flow Probe Extension Cable

LVP Measurement to IH-SR Working Heart



IHSR-WH-LVPM 73-4037 ●●●●●

LVP measurement in mouse Working Heart

Includes:

- Millar Pressure Catheter 1F
- Connecting Cable
- TAM-A Amplifier
 - Utilizes 2 Slot Units
- Adapter Port for Microtip Catheter

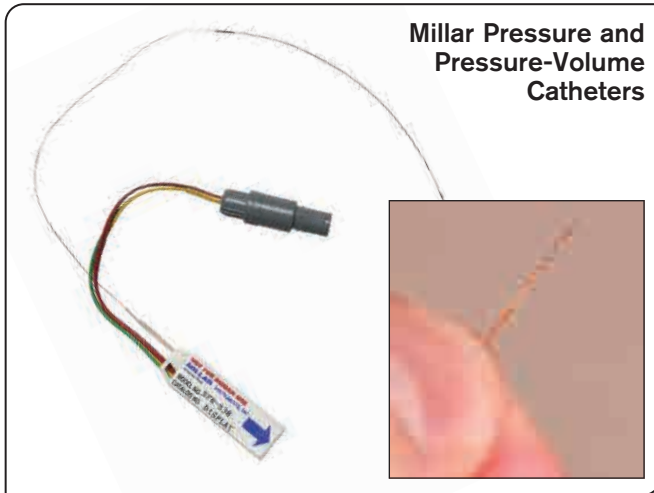
IH-WH-LVPR 73-4038 ●●●●●

LVP measurement in rat and guinea pig Working Heart

Includes:

- Millar Pressure Catheter 2F
- Connecting Cable
- TAM-A Amplifier
 - Utilizes 2 Slot Units
- Adapter Port for Microtip Catheter

IH-SR Working Heart Options: Pressure Volume Measurement

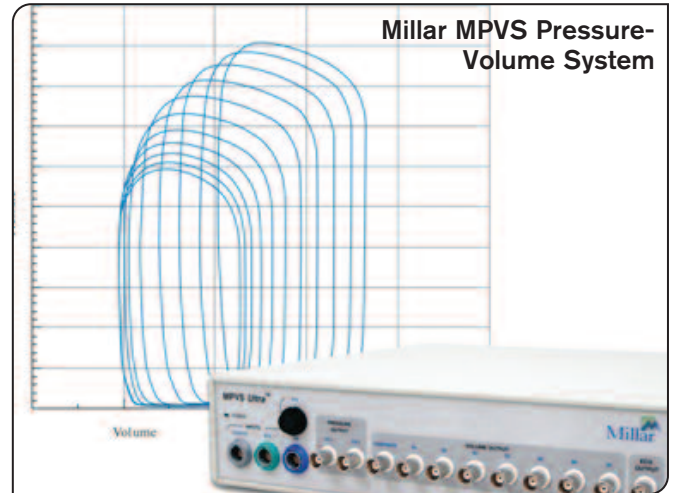


IHSR-WH-PVM 73-4043 ●●●●●

Pressure-volume loop measurement in mouse Working Heart

Includes:

- Millar Pressure Volume Catheter 1F
 - Total Length 20 cm
 - Conductance Electrode Spacing 4.5 mm
- MPVS Ultra (Single Segment) Pressure Volume Hardware and Control Software
- Cables and Calibration Accessories



IH-WH-PVR 73-4044 ●●●●●

Pressure-volume loop measurement in rat Working Heart

Includes:

- Millar Pressure Volume Catheter 1.4F
 - Total Length 27 cm
 - Conductance Electrode Spacing 9 mm
- MPVS Ultra (Single Segment) Pressure Volume Hardware and Control Software
- Cables and Calibration Accessories

IH-PVSOFT 73-4410 ●●●●●

Pressure volume loop analysis software

Choose this option when the ISOHEART Data Acquisition package (DAQ-HSE-IH) is chosen.

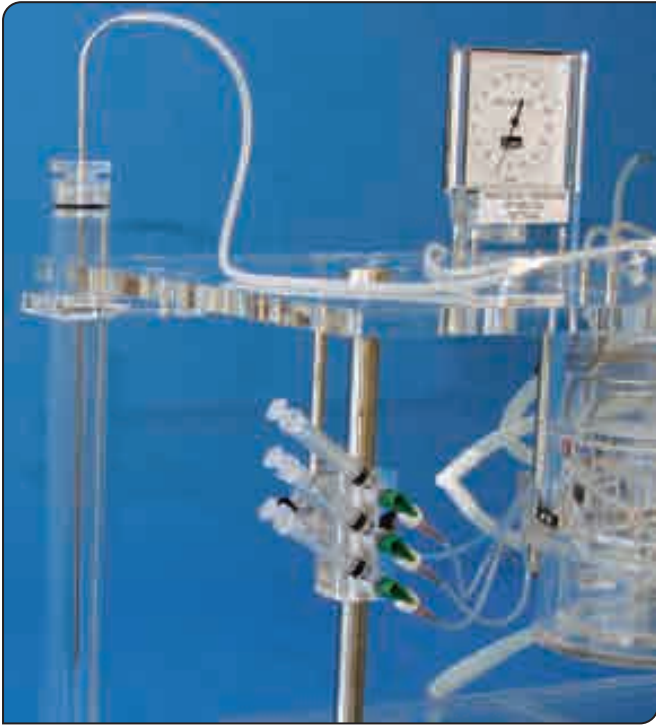
*PV Loop Analysis Module is included with the PowerLab Data Acquisition package options.

Includes:

- ISOHEART Software Module for PV Loop Display
- PVAN Ultra Evaluation Software

IH-SR Working Heart Options:

Increased Preload Pressure - Gottlieb Valve



IHSR-GOTT 73-0158 ●●●●●

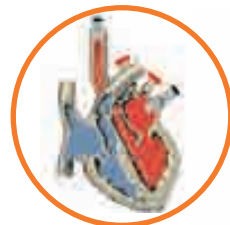
Gottlieb valve for increase preload pressure in Working Heart

Choose this option when you need to create left atrial preload pressures that are greater than 11 mmHg. The Gottlieb Valve allows you to create preload pressures outside of the standard physiological range (up to 30 mmHg) in order to simulate a disease state.

IH-SR Working Heart References:

1. Bozeat ND, Xiang SY, Ye LL, Yao TY, Duan ML, Burkin DJ, Lamb FS, Duan DD, (2011). Activation of volume regulated chloride channels protects myocardium from ischemia/reperfusion damage in second-window ischemic preconditioning. *Cell Physiol Biochem.*, 28(6):1265-78.
2. Chen H, Liu LL, Ye LL, McGuckin C, Tamowski S, Scowen P, Tian H, Murray K, Hatton WJ, Duan D, (2004). Targeted inactivation of cystic fibrosis transmembrane conductance regulator chloride channel gene prevents ischemic preconditioning in isolated mouse heart. *Circulation*, 110(6):700-4.
3. Cheng L, Ding G, Qin Q, Huang Y, Lewis W, He N, Evans RM, Schneider MD, Brako FA, Xiao Y, Chen YE, Yang Q, (2004). Cardiomyocyte-restricted peroxisome proliferator-activated receptor- δ deletion perturbs myocardial fatty acid oxidation and leads to cardiomyopathy. *Nat Med.*, 10(11):1245-50.
4. Frey N, Franz WM, Gloeckner K, Degenhardt M, Müller M, Müller O, Merz H, Katus HA, (2000). Transgenic rat hearts expressing a human cardiac troponin T deletion reveal diastolic dysfunction and ventricular arrhythmias. *Cardiovasc Res*, 47(2):254-64.
5. Itter G, Jung W, Juretschke P, Schoelkens BA, Linz W, (2004). A model of chronic heart failure in spontaneous hypertensive rats (SHR). *Lab Anim.*, 38(2):138-48.
6. Karck M, Tanaka S, Bolling SF, Simon A, Su TP, Oeltgen PR, Haverich A, (2001). Myocardial protection by ischemic preconditioning and delta-opioid receptor activation in the isolated working rat heart. *J Thorac Cardiovasc Surg.*, 122(5):986-92.
7. Lenski M, Kazakov A, Marx N, Böhm M, Laufs U, (2011). Effects of DPP4 inhibition on cardiac metabolism and function in mice. *J Mol Cell Cardiol.*, 51(6):906-18.
8. Liu J, Wang P, Luo J, Huan Y, He L, Yang H, Li Q, Wu S, Zhelyabovska O and Yang Q*, (2011). PPAR β/δ activation in adult hearts facilitates mitochondrial function and protects cardiac performance under pressure-overload condition. *Hypertension*, 57(2):223-30. NIHMSID # 265863
9. Luo J, Wu S, Liu J, Li Y, Yang H, Kim T, Zhelyabovska O, Ding G, Zhou Y, Yang Y and Yang Q*, (2010). Conditional PPAR γ knockout from cardiomyocytes of adult mice disturbs myocardial fatty acid utilization. *American Journal of Translational Research*, 3(1):61-72.
10. Merx MW, Liehn EA, Graf J, van de Sandt A, Schaltenbrand M, Schrader J, Hanrath P, Weber C, (2005). Statin treatment after onset of sepsis in a murine model improves survival. *Circulation*, 112(1):117-24.
11. Müller OJ, Lange M, Rattunde H, Lorenzen HP, Müller M, Frey N, Bittner C, Simonides W, Katus HA, Franz WM, (2003). Transgenic rat hearts overexpressing SERCA2a show improved contractility under baseline conditions and pressure overload. *Cardiovasc Res.*, 59(2):380-9.
12. Panek AN, Posch MG, Alenina N, Ghadge SK, Erdmann B, Popova E, Perrot A, Geier C, Dietz R, Morano I, Bader M, Ozelik C, (2009). Connective tissue growth factor overexpression in cardiomyocytes promotes cardiac hypertrophy and protection against pressure overload. *PLoS One*, 4(8):e6743.
13. Reil JC, Hohl M, Kazakov A, Oberhofer M, Kaestner L, Mueller P, Adam O, Maack C, Lipp P, Mewis C, Allestie M, Laufs U, Böhm M, Neubergler HR, (2010). Cardiac Rac1 overexpression in mice creates a substrate for atrial arrhythmias characterized by structural remodelling. *Cardiovasc Res.*, 87(3):485-93.
14. Ruetten H, Badorff C, Ihling C, Zeiher AM, Dimmeler S, (2001). Inhibition of caspase-3 improves contractile recovery of stunned myocardium, independent of apoptosis-inhibitory effects. *J Am Coll Cardiol.*, 38(7):2063-70.

IH-5 Working Heart: The Fully-Ejecting Working Heart Model for Large Rodents



PRELOAD RESERVOIR

- Preload Pressure Adjustment
 - The Height of the Constant Level Fluid Column Corresponds to Preload Pressure
- Built-In Stopcock For Rapid Control of Atrio-Ventricular Flow
- Integrated Ultrasonic Flowprobe for Cardiac Output Measurement

FLOW MEASUREMENT

- Phasic Real-Time Direct Flow Measurements
 - Aortic Flow
 - Atrial Flow
 - Coronary Flow
- Fully Integrated Flow Probes
- Solid State Physiological Perfusion Circuit Ensures Non-Turbulent, Laminar Flow

PLUGSYS

- Modular System Allows Easy Upgrade of Functionality from Langendorff to Working Heart
- Expands to a Second PLUGSYS Case for Working Heart with Electrophysiology
- Compact, Rack-Mountable Space-Saving Arrangement

ATRIAL CANNULA BLOCK

- Integrated Bubble Trap and Syringe for Containing and Removing any Air Bubbles that may be Swept into Atrium Head
- Preload Pressure is Measured by Transducer Connected to the Atrial Block
- Atrial Filling is Optimized by the Inclusion of an Elastic Diaphragm Connected to Atmospheric Pressure

AORTIC BLOCK

- Adjustable Afterload Resistor (Starling Resistor) Built-in to the Aortic Block for Setting Peripheral Resistance in the Working Heart Preparation
 - 0-300 mmHg Adjustment Range
 - Precise Adjustment of Cardiac Afterload to Simulate Hypo-, Normo-, or Hypertensive States
 - Improved Arterial Pressure Evaluation Without the Risk of Damage to Heart Valves
- Oscillation Dampening System Improve Dynamic Characteristics of the System by Mimicking Peripheral Compliance, Allowing Near Physiological Pressure Waveforms
- Integrated Pathway for Insertion of a Pressure or Pressure Volume Catheter into the LV

FEATURES & BENEFITS

- Assessment of External Heart Work Under Adjustable Load
- Reduced Line Resistance Engineered to Exceed Species Flow for Optimal Atrial Filling
- Rapid and Easy Switching Between Working Heart and Langendorff Modes
- Compact, Smaller Bench Footprint and Vertical Clearance (No High Water Column Required)
- Low Flow Resistance and Dead Space Volume for Highly Reproducible and Accurate Results
- Low Volume Drug Injection Pathway
- Solid State Perfusion Technology
- Proprietary Patented Afterload System to Eliminate Water-Column Bouncing
- Laminar Flow Lines to Improve Accuracy of Flow Measurement

IH-5 Working Heart



FEATURES & BENEFITS

- Provides a valuable tool for the researcher who wants to study cardiac function and metabolism
- Combines the advantages of an isolated organ preparation with *In situ*-like perfusion features
- Allows a more comprehensive monitoring of functional parameters, the calculation of the external heart work and mechanical efficiency, and a considerably higher sensitivity for various experimental manipulations
- Compact design, optimized for each species: rabbit, rat, guinea pig
- Allows rapid and easy switching between Working Heart and Langendorff modes
- Patented physiological afterload system (Starling Resistor) eliminates the conventional water column to create an afterload. The result is vastly improved arterial pressure evaluation without the risk of damage to heart valves.
- Reduced line resistance, optimized to exceed species flow producing optimal atrial filling
- Proprietary patented afterload system to eliminate water column bouncing
- Assessment of external heart work under adjustable load
- Small flow resistance and low dead space volume for highly reproducible and accurate results
- Solid state perfusion technology mimics *in vivo* perfusion and prevents measurement artifact

MEASURED SIGNALS AND CALCULATED PARAMETERS ON AN IH-5 WORKING HEART SYSTEM:

All signals from Langendorff plus the following signals can be recorded:

- Preload Pressure (Left Atrial Preload/ Ventricular Filling Pressure)
- Afterload Pressure (Aortic Pressure for Calculation of Systolic and Diastolic Pressure)
- Left Ventricular Pressure or Pressure Volume Loops
- Cardiac Output (Atrial Flow), Aortic, and Coronary Flow (Either Direct or by Subtraction of CO-Aortic Flow)

**IH5-WH 73-4411 (115V)
or 73-4412 (230V)** ●●●●●

Working Heart option to IH-5 Core System

The Working Heart option must be paired with the system configuration detailed in the chart on page 27 "Langendorff Working Heart-Ready Configuration." If you are upgrading from a Working Heart-Ready configuration or are building a Working Heart System from scratch, then simply add the Working Heart Option and one or both of the species-specific options below.

Includes:

- Left Atrial Cannulating System
 - Preload Reservoir (2-7 mL capacity)
 - Movable Atrium Connection Adapter
 - Holder for Preload Pressure Transducer
- Peristaltic Pump with Tubing
- Preload Pressure Measurement
 - Venous Pressure Transducer
 - TAM-A Amplifier
 - Utilizes 2 Slot Units

IH5-WH-RGP 73-4413 ●●●●●

Working Heart left atrial cannula for rat & guinea pig hearts, 2.3 mm OD

IH5-WH-RAB 73-4414 ●●●●●

Working Heart left atrial cannula for rabbit heart, 6.0 mm OD

If you are upgrading from a basic Langendorff system ("Langendorff only Configuration" as detailed in the chart on page 27) please contact our technical team for assistance.

IH-5 Working Heart Options: Cardiac Output Measurement



FEATURES & BENEFITS

- Ultrasonic transit time direct flow measurement – gold standard
- Unique integration of flow probe in atrial perfusion path
- Laminar flow lines improve accuracy of flow measurement
- Multiple flow probe sizes available, depending on species
- Compact design to reduce line resistance, minimize volume and reduce temperature loss

IH5-CO-RGP 73-4415 ●●●●●

Cardiac output for rat & guinea pig heart

Includes:

- 2.5 PSB Perivascular Flow Probe
- In-line Flow Probe Adapter for IH-5 Atrial Block
- TTFM PLUGSYS Flowmeter
 - Utilizes 4 Slot Units
- Flow Probe Extension Cable

IH5-CO-RAB 73-4416 ●●●●●

Cardiac output for rabbit heart

Includes:

- 4.0 PSB Perivascular Flow Probe
- In-line Flow Probe Adapter for IH-5 Atrial Block
- TTFM PLUGSYS Flowmeter
 - Utilizes 4 Slot Units
- Flow Probe Extension Cable



IH-WH-LVPR 73-4038 ●●●●●

LVP measurement in rat, guinea pig & rabbit Working Heart

Includes:

- Millar Pressure Catheter 2F
- Connecting Cable
- TAM-A Amplifier
 - Utilizes 2 Slot Units
- Adapter Port for Microtip Catheter

IH-WH-PVR 73-4044 ●●●●●

Pressure-volume loop measurement in rat Working Heart

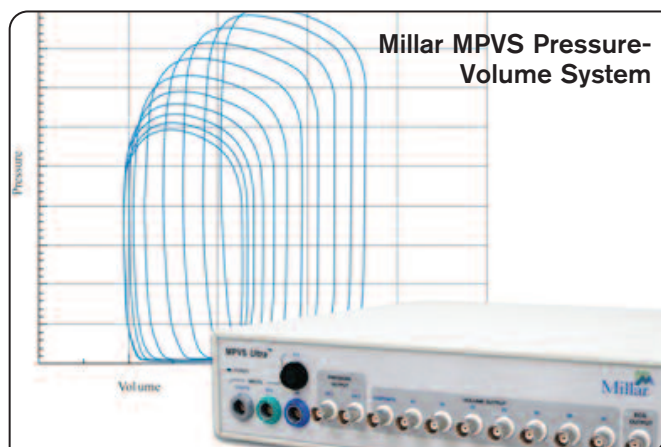
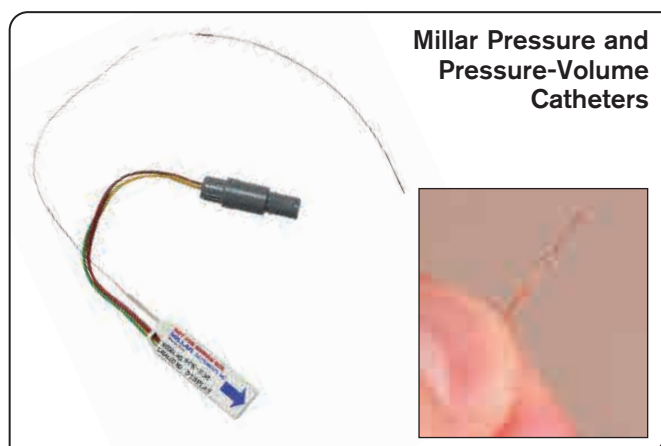
Includes:

- Millar Pressure Volume Catheter 1.4F
 - Total Length 27 cm
 - Conductance Electrode Spacing 9 mm
- MPVS Ultra (Single Segment) Pressure Volume Hardware and Control Software
- Cables and Calibration Accessories

Additional Catheter Size available for rat and guinea pig heart:

Pressure-Volume Catheter	
ORDER #	PRODUCT
IH2 72-9937	2 Fr Pressure Volume Catheter, Single Segment, 6.0 mm Electrode Spacing for Small Rat Heart
IH2 72-9746	2 Fr Pressure Volume Catheter, Single Segment, 12.0 mm Electrode Spacing for Guinea Pig or Large Rat Heart
IH2 72-9747	2 Fr Pressure Volume Catheter, Single Segment, 14.0 mm Electrode Spacing for Guinea Pig or Large Rat Heart

Pressure-Volume Loop Measurement in Guinea Pig or Rabbit Working Heart



Larger hearts often require multi-segment catheters for accurate volume measurement – the minimum size of these catheters is 3Fr. The IH-5 system can accommodate catheters up to 2Fr via the dedicated access path; however, for larger hearts it is recommended to instead use the apical puncture method.

As the larger pressure volume catheters have multiple conductance electrodes arrayed at regular intervals they require the use of the standard MPVS Pressure Volume Control Unit. Additionally, due to the variance in the sizes of the left ventricles of larger hearts, the catheters are not pre-packaged with the hardware and the software, and need to be purchased separately.

IH5-WH-PVRAB 73-4417 ●●●●●

Includes:

- MPVS Multi-Segment Pressure Volume Control Unit Hardware and Software
- Rho Calibration Cuvette
- MPVS Hardware Cable Pack
- BNC Cable Pack for Connection to Most Data Acquisition Systems

CHOOSING THE RIGHT PV CATHETER

Choosing the correct PV Catheter requires the knowledge of ventricle size of the rat, guinea pig, or rabbit heart with which you are working. Remove the heart from a typical subject (or from the largest and smallest subjects if you are using a range) you will likely be using for experiments. Cut the heart longitudinally from the aortic valve to the apex of the left ventricle and measure the distance between these two points. Once you know this distance, you will be able to choose the appropriate PV catheter from the below options:

Pressure-Volume Catheters	
ORDER #	PRODUCT
IH2 72-9750	2 Fr; Single Field; Electrodes: 6; Spacing: 3.0 mm; Total Length 12.5 cm
IH2 72-9751	2 Fr; Single Field; Electrodes: 8; Spacing: 3.0 mm; Total Length 12.5 cm
IH2 72-9752	3 Fr; Single Field; Electrodes: 10; Spacing: 3.0 mm; Total Length 105 cm
IH2 72-9753	3 Fr; Single Field; Electrodes: 10; Spacing: 4.5 mm; Total Length 105 cm
IH2 72-9962	3 Fr; Single Field; Electrodes: 10; Spacing: 4.0 mm; Total Length 105 cm
IH2 72-9754	3 Fr; Dual Field; Electrodes: 10; Spacing: 2.5 mm; Total Length 120 cm

All of the above multi-segment catheters are straight-tipped.

IH-PVSOFT 73-4410 ●●●●●

Pressure volume loop analysis software

Choose this option when the ISOHEART Data Acquisition package (DAQ-HSE-IH) is chosen, on page 58.

Includes:

- ISOHEART Software Module for PV Loop Display
- PVAN Ultra Evaluation Software

NOTE

A PV Loop Analysis Module is included with the PowerLab Data Acquisition package options, on page 59. ●●●●●

IH-5 Working Heart References:

1. Kröner A, Seitelberger R, Schirnhöfer J, Bernecker O, Mallinger R, Hallström S, Ploner M, Podesser BK, (2002) Diltiazem during reperfusion preserves high energy phosphates by protection of mitochondrial integrity. *Eur J Cardiothorac Surg*, 21(2):224-31.
2. Podesser BK, Schirnhöfer J, Bernecker OY, Kröner A, Franz M, Semsroth S, Fellner B, Neumüller J, Hallström S, Wolner E, (2002). Optimizing ischemia/reperfusion in the failing rat heart—improved myocardial protection with acute ACE inhibition. *Circulation*, 106(12 Suppl 1):I277-83
3. Rosada B, Wagner SM, Kuschekowitz F, Buddensiek M, Laczkovics AM, Stegmann TJ, (1999). Monitoring the Function of the Heart Using the Monophasic Action Potential – Investigation in the Langendorff Perfused Rabbit Heart. *Progress in Biomed Res*, June 1999, 202-206
4. Semsroth S, Fellner B, Trescher K, Bernecker OY, Kalinowski L, Gasser H, Hallström S, Malinski T, Podesser BK, (2005). S-nitroso human serum albumin attenuates ischemia/reperfusion injury after cardioplegic arrest in isolated rabbit hearts. *J Heart Lung Transplant*, 24(12):2226-34. Epub 2005 Nov 17.

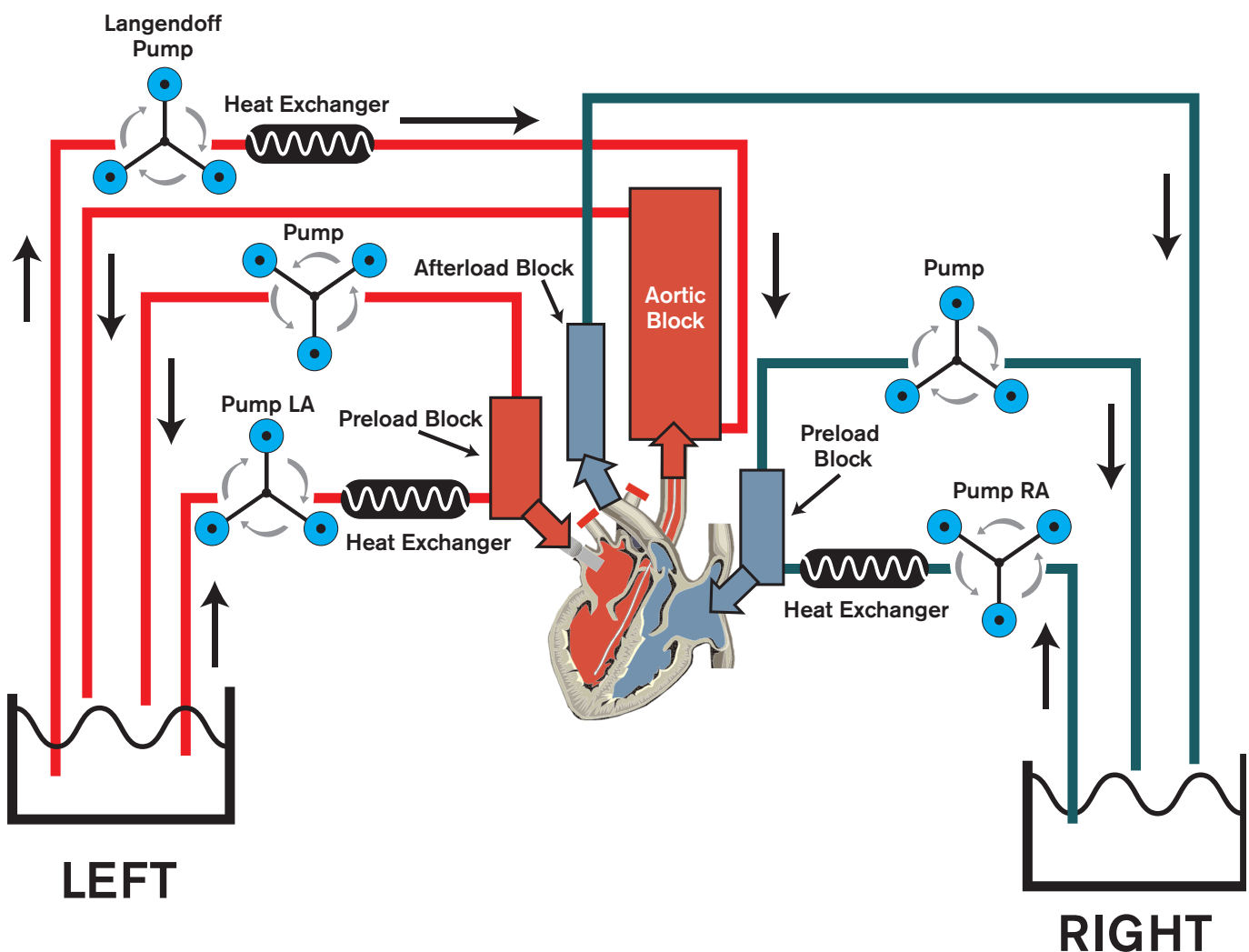
References Continued on page 78.

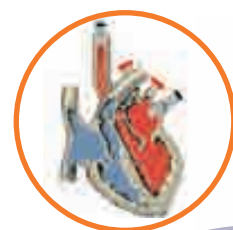
Working Heart & Biventricular Working Heart

WHAT'S THE DIFFERENCE?

In normal **Langendorff and Ejecting Working Heart** studies (acc. to NEELY) measurements are done only on the left ventricle. The right heart side is nourished via the coronaries but does not fill with and eject fluid. Right heart diseases are under increasing scrutiny as the effects of chronic pulmonary conditions have been discovered to create distinct right heart pathophysiology. Additionally, advances in cardiac electrophysiology have characterized spiral patterns and complex electrical waves of activity which underlie arrhythmic conditions, the study of which may be more relevant in a fully biventricular ejecting heart model. *Ex vivo* perfusion of heart isolated from diseased models with Right Ventricular Hypertrophy (RVH) following prolonged partial pulmonary ligation is also possible, allowing the same studies that have been done previously on normal hearts to be replicated on RVH hearts.

Our **Biventricular Working Heart** system is based on the IH-5 Working Heart platform but with an added, decoupled perfusion circuit for the right heart. The preload pressure of the right heart is, like the left heart, achieved with a water column, only this time set to the lower pressures of the right atrium (< 5 mmHg). The patented afterload system is used both in the aortic block to simulate peripheral resistance and in the right ventricular afterload block to simulate lung resistance. Both afterloads can be set by the researcher over a wide range covering normal, hypotensive and hypertensive pressures.





IH5-BI Biventricular Working Heart: The Most Physiological Isolated Perfused Heart Model for Large Rodents



TEMPERATURE CONTROL

- Perfusate is Re-Warmed in Heat Exchangers Located Proximally to the Cannulae to Minimize Heat Loss Through Tubing
- Large Jacketed Heart Chamber Fully Encloses the Right and Left Atrium Blocks

RIGHT VENTRICULAR AFTERLOAD

- Adjustable Right Ventricular Afterload Pressure is Set by Knob on Pressure Gauge
- Patented Membrane Resistor Simulates Lung Resistance
- Allows the Study of Pulmonary Artery Hypertension

LEFT ATRIAL BLOCK

- Preload Pressure Adjustment
 - The Height of the Constant Level Fluid Column Corresponds to Preload Pressure
 - Preload Pressure is Measured by Transducer Connected to the Atrial Block
- Built-In Stopcock For Rapid Control of Atrio-Ventricular Flow
- Integrated Ultrasonic Flowprobe for Cardiac Output Measurement
- Integrated Bubble Trap and Syringe for Containing and Removing any Air Bubbles that may be Swept into Atrium Head
- Atrial Filling is Optimized by the Inclusion of an Elastic Diaphragm Connected to Atmospheric Pressure

AORTIC BLOCK

- Adjustable Afterload Resistor (Starling Resistor) Built-in to the Aortic Block for Setting Peripheral Resistance in the Working Heart Preparation
 - 0-300 mmHg Adjustment Range
 - Precise Adjustment of Cardiac Afterload to Simulate Hypo-, Normo-, or Hypertensive States
 - Improved Arterial Pressure Evaluation Without the Risk of Damage to Heart Valves
- Oscillation Dampening System Improve Dynamic Characteristics of the System by Mimicking Peripheral Compliance, Allowing Near Physiological Pressure Waveforms
- Integrated Pathway for Insertion of a Pressure or Pressure Volume Catheter into the LV

FEATURES & BENEFITS

- Assessment of External Heart Work Under Adjustable Load for Right Heart and Left Heart
- Reduced Line Resistance Engineered to Exceed Species Flow for Optimal Atrial Filling
- Rapid and Easy Switching Between Biventricular, Left Working Heart and Langendorff Modes
- Compact, Smaller Bench Footprint and Vertical Clearance (No High Water Column Required)
- Low Flow Resistance and Dead Space Volume for Highly Reproducible and Accurate Results
- Low Volume Drug Injection Pathway
- Solid State Perfusion Technology
- Proprietary Patented Afterload System to Eliminate Water-Column Bouncing and Resulting Valve Damage
- Laminar Flow Lines to Improve Accuracy of Flow Measurements

RIGHT ATRIAL BLOCK

- Preload Pressure Adjustment
 - The Height of the Constant Level Fluid Column Corresponds to Right Atrial Preload Pressure
 - Preload Pressure is Measured by Transducer Connected to the Atrial Block
- Built-In Stopcock For Rapid Control of Atrio-Ventricular Flow in the Right Heart
- Optional Integrated Ultrasonic Flowprobe for measurement of Right Heart Flow
- Atrial Filling is Optimized by the Inclusion of an Elastic Diaphragm Connected to Atmospheric Pressure

Biventricular Working Heart



FEATURES & BENEFITS

- Provides a valuable tool for the researcher who wants to study whole-heart cardiac function
- Applications include calcium homeostasis, drug effects on right heart electrophysiology and contractility, ischemia/reperfusion effects on right heart, effects of right ventricular hypertrophy on cardiac function, whole heart imaging
- Combines the advantages of an isolated organ preparation with *in situ*-like perfusion features
- Allows a more comprehensive monitoring of functional parameters, the calculation of the external heart work and mechanical efficiency, and the highest sensitivity for various experimental manipulation in *ex vivo* isolated heart preparations
- Allows rapid and easy switching between Biventricular Working Heart, left Working Heart and Langendorff modes
- All of the same features and benefits of the IH-5: Compact, no high water columns, low resistance laminar flow paths and low system volume
- Assessment of external heart work under adjustable load for both right and left heart
- Modular design to integrate more applications in the future
- Solid State Perfusion Technology (S²P²C) mimics *in vivo* Perfusion and Prevents Measurement Artifact

MEASURED SIGNALS AND CALCULATED PARAMETERS ON A BIVENTRICULAR WORKING HEART SYSTEM:

The Following Signals can be Recorded:

- Left Atrial Preload Pressure (Left Ventricular Filling Pressure)
- Right Atrial Preload Pressure (Right Ventricular Filling Pressure)
- Afterload Pressure (Aortic Pressure for Calculation of Systolic and Diastolic Pressure)
- Right Ventricular Afterload (Pulmonary Artery Pressure)
- Left Ventricular Pressure or Pressure Volume Loops
- Right Ventricular Pressure or Pressure Volume Loops
- Cardiac Output (Left Atrial Flow), Aortic, Right Atrial Flow, and Coronary Flow (Subtraction of Aortic Flow from CO or by Subtraction of Right Atrial Flow from Pulmonary Artery Flow)

IH5-BI 73-4419 (115V) or 73-4420 (230V) ●●●●●

Basic Biventricular Working Heart System for rat, guinea pig, and rabbit heart

The Hugo Sachs Elektronik - Harvard Apparatus Biventricular Isolated Working Heart perfusion system utilizes patented flow resistance and compliance chambers to faithfully mimic the *in vivo* cardiac preloads and afterloads for both normal and diseased states in medium to large models (rat, guinea pig, rabbit). The exclusive features of the system create the most physiological isolated heart environment closely resembling the actual resistance of the peripheral vasculature while allowing the entire heart to work as it does *in vivo*, setting a new standard for isolated heart research. This fully-integrated system allows for in-depth *ex vivo* studies of the effects of Pulmonary Artery Hypertension (PAH), Hypertrophy (RVH), COPD, ARCV, Emphysema and a variety of other diseases characterized by pulmonary vascular dysfunction and right heart pathophysiology.

The system allows measurement of a wide range of cardiovascular parameters with unsurpassed fidelity, such as single ECG Lead II and Single Epicardial Monophasic Action Potential. Integration of High Fidelity Pressure Volume Catheters for right and left ventricle PV Loop Measurement is also available.

Biventricular Working Heart

(continued)

The complete system includes virtually everything you need to accomplish the basic Biventricular Working Heart experiment, only requiring the addition of the appropriate species-specific package. For detailed descriptions of all system extensions and options see pages 30, 53-60. Contact our expert technical team if you need assistance with system configuration, application support or custom design requests.

Includes:

- Biventricular Working Heart Base System
- Thermocirculator
- 2 x Analog Roller Pump for Right and Left Atrial Supply
- Analog Pump for Langendorff Preparation
- PLUGSYS Basic System Case 603
 - Core System Utilizes 8 of 20 total Slot Units
- Aortic/Afterload Pressure Measurements
 - Pressure Transducer
 - TAM-D PLUGSYS Transducer Amplifier Module
- Left Atrial Preload Pressure
 - Pressure Transducer
 - TAM-D PLUGSYS Transducer Amplifier Module
- Right Atrial Preload Pressure
 - Pressure Transducer
 - TAM-D PLUGSYS Transducer Amplifier Module
- Right Ventricular Afterload Pressure
 - Pressure Transducer
 - TAM-D PLUGSYS Transducer Amplifier Module

For a working unit, the core system requires the selection of one of the options BIV-CAN-R/GP or BIV-CAN-RAB.

BIV-CAN-R/GP 73-4450 ●●●●●

Rat/guinea pig Biventricular cannula set

Includes:

- Aortic Cannula Set for rat/guinea pig hearts
 - 2.5 mm OD
 - 3.0 mm OD
- Left Atrium Cannula, 2.3 mm OD
- Right Atrium Cannula, 2.3 mm OD
- Pulmonary Artery Cannula Set
 - 2.5 mm OD
 - Mini-Ball Joint Mounting Kit

BIV-CAN-RAB 73-4451 ●●●●●

Rabbit Biventricular cannula set

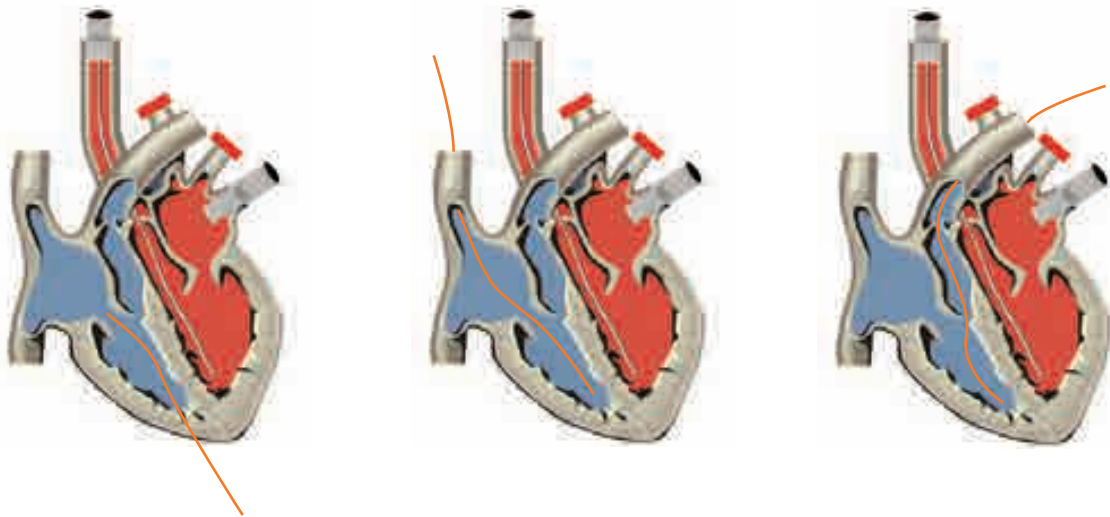
Includes:

- Aortic Cannula for rabbit hearts
 - 3.0 mm OD
 - 4.0 mm OD
 - 5.0 mm OD
- Left Atrium Cannula, 2.3 mm OD
- Right Atrium Cannula, 2.3 mm OD
- Pulmonary Artery Cannula Set
 - 2.5 mm OD
 - Mini-Ball Joint Mounting Kit

All options compatible with the IH-5 Working Heart System are compatible with the IH5-BI Biventricular Working Heart System, excluding Multi-ECG and Multi-MAP. See pages 30, 53-60.

Biventricular Heart System Options: Right Ventricle Pressure and Pressure Volume Measurement

INTRODUCING THE PRESSURE VOLUME CATHETER:



There are three possibilities for introduction of the Pressure or Pressure Volume Catheter into the Right Ventricle: apical puncture, via the right superior vena cava, or via the pulmonary artery. *In vivo* it is most commonly accomplished via the jugular vein using the Seldinger Technique. In the *ex vivo* preparation on the Biventricular system, the most successful methods would be either apical puncture or via the pulmonary artery as the Right Atrial Cannulating Block has no direct access port through which a PV catheter could be passed.

Choosing the Correct RV Pressure Volume Catheter:

In general the same catheters used for Left Ventricular PV Loop can be used; however, because the RV is smaller, a shorter electrode spacing is recommended. For example, a small rat heart would often require a 4.5 mm single segment mouse pressure volume catheter while the left ventricle would require a 6.0 mm spacing. A large rat would use a 6.0 mm spacing in the RV and a 9.0 mm spacing in the LV. As with LV-PV catheter determination, the right ventricle of the heart(s) of the representative species should be cut lengthwise and measured for matching the appropriate catheter.

Analyzing the Right Ventricular PV Loop:

PV Analysis software has been designed for traditional left ventricular PV Loops. Since RV-PV Loops in normal animals tend to be more triangular the identification of end systole and end diastole is more difficult for the software to accomplish. Most often the researcher will need to rely upon their own algorithms if they need to alter the location of systole and diastole provided by the software.

Biventricular Working Heart References:

1. Asfour H, Wengrowski AM, Jaimes Iii R, Swift LM, Kay MW, (2012). NADH Fluorescence Imaging of Isolated Biventricular Working Rabbit Hearts. *J Vis Exp.*, (65). pii: 4115. doi: 10.3791/4115.

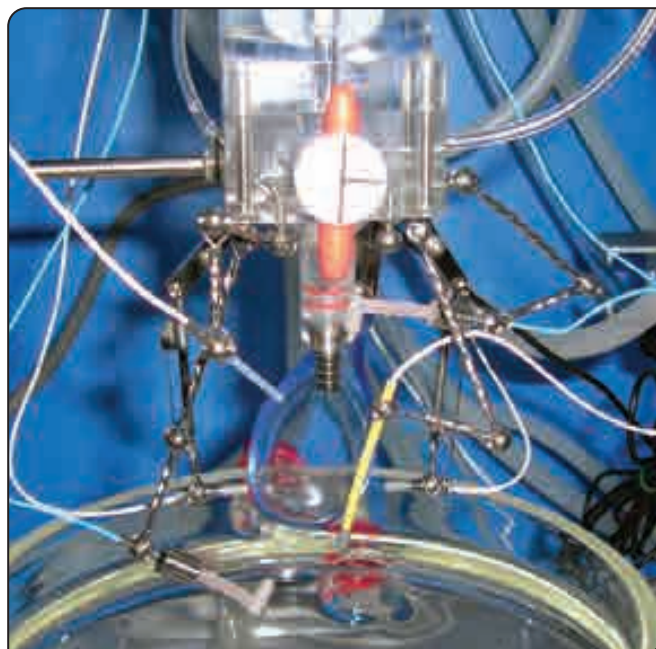
NOTE

Please refer to the IH-5 pages 45-46 for Pressure and Pressure Volume Measurement and Catheter options ●●●●●

Specialized Options for IH Physiology Systems: Electrophysiology & Safety Pharmacology

FEATURES & BENEFITS

- Mini monophasic action potential electrodes for epicardial and endocardial recording, with dedicated holders
- Precision MAP electrodes with dedicated holders allow easy positioning on the heart
- Small electrodes allow multiple ECG and MAP signals to be recorded even on mouse hearts
- Mini ECG electrodes with dedicated holders
- Flexible ECG electrodes follow the heart beat, dedicated holders allow easy positioning on the heart
- Optimized coaxial pacing electrode
- Reduced stray fields from the pacing electrode for more accurate recordings



MONOPHASIC ACTION POTENTIAL

The Monophasic Action Potential (MAP) electrodes made by Hugo Sachs Elektronik work based on the principle of Franz *et al*¹ whereby firm, stable contact of the MAP electrode results in a high-quality MAP. MAP recording has been utilized in cardiac physiology for decades as it allows regional assessment of the electrophysiological state of the intact heart. MAP recording is essential to researchers who study atrial fibrillation, arrhythmias, anti-arrhythmic drugs, ischemia, depolarization and repolarization cycles, activation time, and mechanisms of action of various drugs.

For the addition of MAP recording to your Isolated Perfused Heart system, we have a number of options.

IHSR-MAP-M 73-4025 ●●●●●

Measurement of single epicardial MAP on mouse heart

Choose this option if you are adding a MAP measurement to a Mouse heart recording on the IH-SR Core System.

Includes:

- Micro MAP Tip Electrode
- Link for Higher Loading for Precise Placement and Stabilization of Electrode
- Opposite Holder to provide counterforce to the heart opposite the MAP Electrode
- Biopotential Amplifier and Connection Cable
 - Utilizes 2 Slot Units

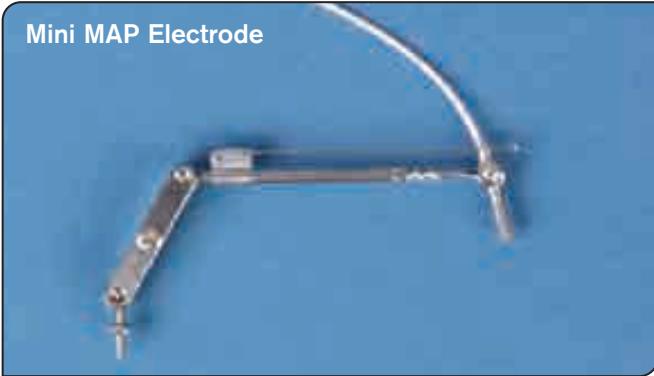
Reference:

1. Franz MR, Burkhoff D, Spurgeon H, Weisfeldt ML, Lakatta EG (1986). In vitro validation of a new cardiac catheter technique for recording monophasic action potentials. *Eur Heart J*, 7: 34-41.



Specialized Options for IH Physiology Systems: Electrophysiology & Safety Pharmacology

Mini MAP Electrode



IHSR-MAP-RGP 73-4026 ●●●●●

Measurement of single epicardial MAP on rat and/or guinea pig heart

Choose this option if you are adding a MAP measurement to a rat or guinea pig heart recording on the IH-SR Core System.

Includes:

- Mini MAP Tip Electrode
- Holder for MAP Electrode for Precise Placement and Stabilization of Electrode
- Opposite Holder to provide counterforce to the heart opposite the MAP Electrode
- Biopotential Amplifier and Connection Cable
 - Utilizes 2 Slot Units

IH5-MAP-SINGLE 73-4421 ●●●●●

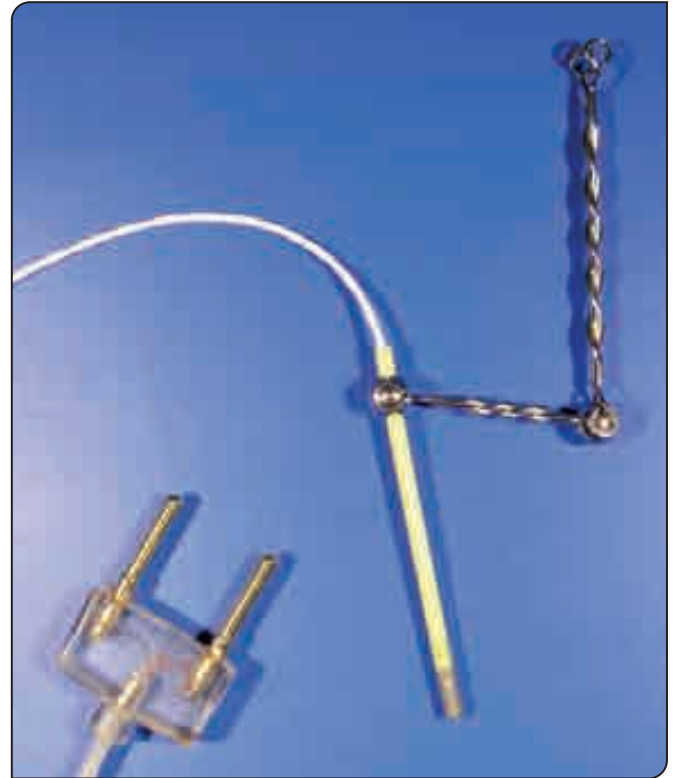
Measurement of single epicardial MAP on rat, guinea pig or rabbit heart

Choose this option if you are adding a MAP measurement to a rat, guinea pig or rabbit heart recording on the IH-5 Core System.

Includes:

- Mini MAP Tip Electrode
- Holders for MAP Electrode for Precise Placement and Stabilization of Electrode
- Large Opposite Holder to provide counterforce to the heart opposite the MAP Electrode
- Biopotential Amplifier and Connection Cable
 - Utilizes 2 Slot Units

Please see pages 32-35 for the special Electrophysiology Workstation options available for the IH-5 System, including multi-MAP and Multi-ECG options.



IH-ENDO-MAP 73-4027 ●●●●●

Measurement of a single endocardial MAP on rat, guinea pig, or rabbit

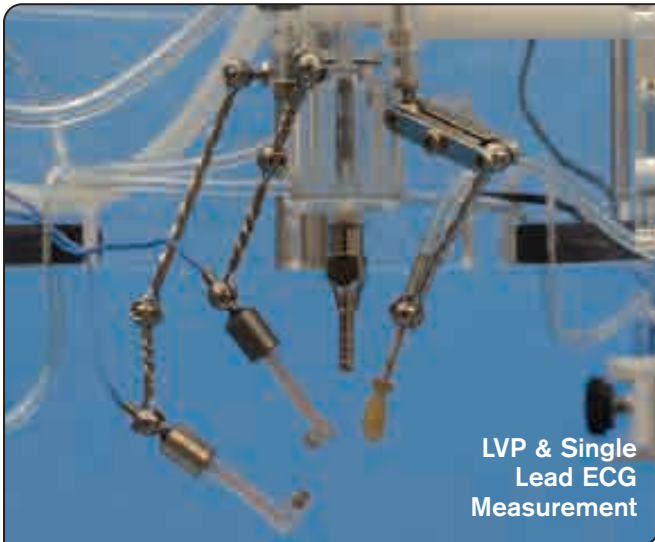
Compatible with both IH-SR and IH-5 Core Systems.

Includes:

- Intracardial MAP-tip Electrode with Holders
- Biopotential Amplifier and Connection Cable
 - Utilizes 2 Slot Units

Specialized Options for IH Physiology Systems:

Cardiac Rhythm Refractory Period



LVP & Single
Lead ECG
Measurement

IH-ECGII 73-4422 ●●●●●

Measurement of ECG lead II on any IH-System, from mouse to rabbit

Includes:

- 2 Contact ECG Electrodes
- Mini Ball Joint Holder System for Universal IH-System Mounting
- ECG Amplifier and Connection Cable
 - Utilizes 2 Slot Units



Stimulator C



Pacing Electrode

IH-PACING 73-4345 (115V) or 73-4024 (230V) ●●●●●

For addition of pacing to IH-Systems for mouse, rat, and guinea pig heart

Includes:

- Mini Coaxial Stimulation Electrode Set
- Stimulator C - Fully Programmable Digital Stimulator

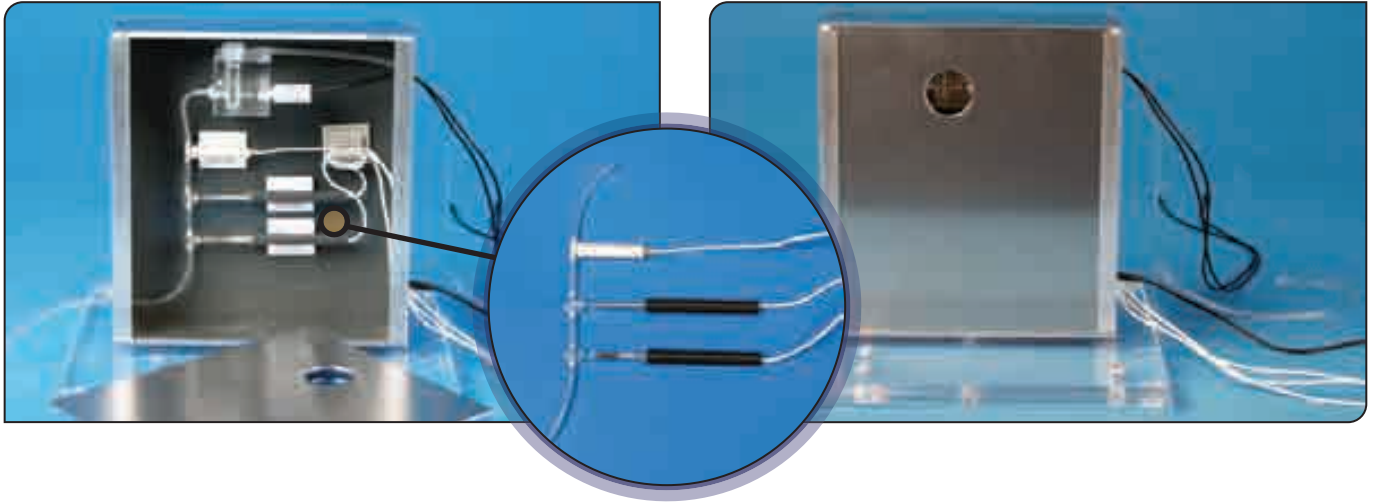
IH5-PACING-RABBIT 73-4452 (115V) or 73-4436 (230V) ●●●●●

For addition of pacing to IH-5 for rabbit heart

Includes:

- Mini Coaxial Stimulation Electrode Set
- Stimulator C - Fully Programmable Digital Stimulator

Specialized Options for IH Physiology Systems: Universal Perfusion Solution Monitor



BIOSEN 73-4304 (115V) or 73-4287 (230V) ●●●●●

Measuring system for pH, pO₂, pCO₂ to Core IH Systems – chemosensors

The Universal Perfusion Solution Monitor permits precise continuous or discontinuous measurement in liquid media or perfusate of these three key parameters: pO₂, pH, & pCO₂. The electrodes are all ion-sensitive chemosensor-based, side stream flow-through electrodes and require a pulsation-free roller pump to deliver constant flow of perfusate through the electrode at flow rates in the range of 0.5-2 ml/min. Because of the high impedance of these sensors, screening or shielding of the measuring circuit is required to protect against electrostatic discharges and other electrical disturbances.

FEATURES & BENEFITS

- Rugged construction
- Noise-free design, no channel crosstalk
- High sensitivity
- Good linearity

Includes:

- Analog Roller Pump & Tubing for Side Stream Sampling
- Shielding Case and Mounting Plate for 3 Sensors

Sensors not included, please choose from the following:

MO2 73-4029 ●●●●●

pO₂ measurement

Includes:

- Mini Flow-Through O₂ Electrode 1/16 in
- OPPM Oxygen Partial Pressure Measurement Amplifier
- pO₂ Zero Solution for Zero Calibration
 - Utilizes 2 slot units

MCO2 73-4031 ●●●●●

pCO₂ measurement

Includes:

- Mini Flow-Through CO₂ Electrode 1/16 in
- EMM Electrometer Amplifier
 - Utilizes 2 slot units

MpH 73-4030 ●●●●●

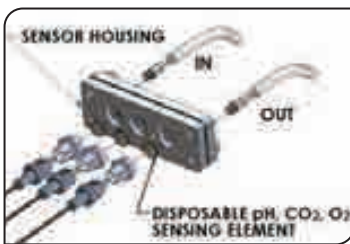
pH measurement

Includes:

- Mini Flow-Through pH Electrode 1/16 in
- Reference Electrode
- pHMM pH Amplifier
 - Utilizes 2 slot units

Specialized Options for IH Physiology Systems:

Fluorescence-Based Biosensors, Detection of pH, O₂, CO₂



POLESTAR BIOSENSORS

Harvard Apparatus – Polestar Fluorescence-based Biosensors represent breakthrough technology in the measurement of typical blood gas parameters in tissue engineering, organ perfusion and general physiology applications.

In contrast to traditional ion-sensitive chemosensors, these optical biosensors use a controlled optical source that emits light signals at specified frequencies which excite an ion-specific sensor spot in contact with the test medium. Changes in the parameter of interest are reported as a proportional change in some characteristic (intensity, phase shift, etc.) of the fluorescence. Because they are inherently self-referencing, this detection technology eliminates the potential for measurement error arising from changes in sample properties (i.e. flow rate, viscosity, etc...) over the duration of an experiment. This ensures stable, drift-free calibration and hence reliable measurements throughout the lifespan of a sensing element. A small analog peristaltic pump is included for side-stream sampling of coronary effluent. The appropriate pulmonary artery (or mouse right atrium) cannula kits can be found on pages 13, 22, 31.

POL 88-0252 ●●●●●

Fluorescence-based optical biosensor

FEATURES & BENEFITS

- Rugged sensors with stable readings over full sensor lifespan
- Automatic gain control ensures optimum measurement reliability
- Sensors and system is shipped pre-calibrated
- Non ion-consumptive detection
- No electrolyte solution or storage solutions needed – low maintenance
- Autoclavable/sterilizable USP class VI-certified sensors

Includes:

- DSP4000 4 Channel Optical Process Monitor with Cables
- Tri-fold Flow Cell for pH, pO₂, pCO₂ with 1/16 in Barbed Connectors for Monitoring Effluent
 - Can be used in-line or as side stream sample, depending on effluent flow rate
- pO₂ Flow Cell for pre-lung O₂ measurement
- Analog Peristaltic Pump with Tubing for Side-Stream Sampling

Specialized Package Additions to All IH Physiology Systems: Data Acquisition and Analysis

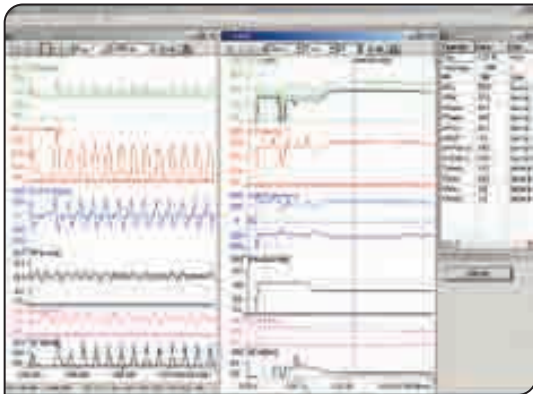
MEASURED SIGNALS & CALCULATED PARAMETERS ON AN IH LANGENDORFF SYSTEM:

The following signals are recorded:

- Isovolumetric Left Ventricular Pressure
- dLVP/dt
- Perfusion Pressure
- Perfusion Flow

The software evaluates the following parameters:

- Systolic and Diastolic LVP
- Heart Rate
- dP/dt Max, dP/dt Min, Contractility Index
- Mean Perfusion Pressure
- Mean Perfusion Flow
- Coronary Resistance



ISOHEART Software

FEATURES & BENEFITS

- **ISOHEART Software**
 - Dedicated for isolated heart experiments
 - Easy data reduction and export
 - Can calculate over 50 parameters
 - Fully pre-configured out of the box for all measurement and analysis
 - Calculates many parameters online
- **PowerLab with LabChart Pro software**
 - Intuitive setup and operation
 - Advanced automated analysis routines
 - Online and offline analysis of ECG
 - Automation of experimental protocols
 - Proven track record

MEASURED SIGNALS & CALCULATED PARAMETERS ON AN IH WORKING HEART SYSTEM:

The following signals are recorded:

- Preload (Left Atrial Preload/Ventricular Filling Pressure)
- Afterload
- Left Ventricular Pressure or Pressure Volume Loops
- Atrial, Aortic, and Coronary Flow

The software evaluates the following parameters:

- All LVP Parameters from Langendorff
- Mean Preload Pressure
- Mean Atrial Flow (CO)
- Mean Aortic Flow
- Mean Coronary Flow
- Coronary Resistance
- Systolic and Diastolic Aortic Pressures

DAQ-HSE-IH16 73-4039 ●●●●●

Data acquisition and evaluation system ISOHEART

Includes:

- 16 Channels of USB Data Acquisition
- ISOHEART Software

DAQ-HSE-IH32 73-4437 ●●●●●

Data acquisition and evaluation system ISOHEART for electrophysiology

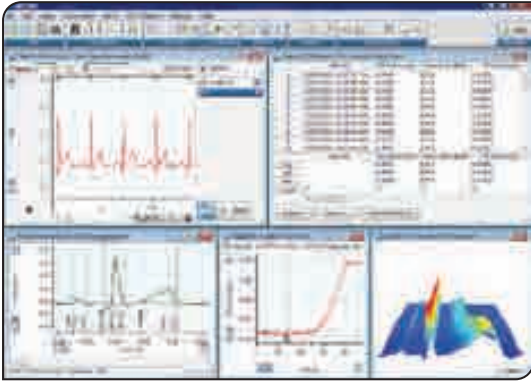
For the researcher who has configured their IH-5 system as a Complete Electrophysiology Workstation, 16 Channels of Data Acquisition are insufficient. In this case the 32 Channel Data Acquisition option should be chosen. Please note that this software option requires the installation of a PCI card in a Desktop Computer with an available PCI slot and cannot be used with a laptop computer.

Includes:

- 32 Channels of Data Acquisition, PCI card
- ISOHEART Software
- 32 Channel Software Expansion Module

Specialized Package Additions to All IH Physiology Systems:

Data Acquisition and Analysis



LabChart Pro Software



DAQ-PWL8P 77-0242 (United States) 73-4453 (International) ●●●●●

Data acquisition system and evaluation system
PowerLab

Choose this option when system configuration includes less than 8 measured parameters

Includes:

- 8 Channel PowerLab Hardware
- LabChart Pro Software



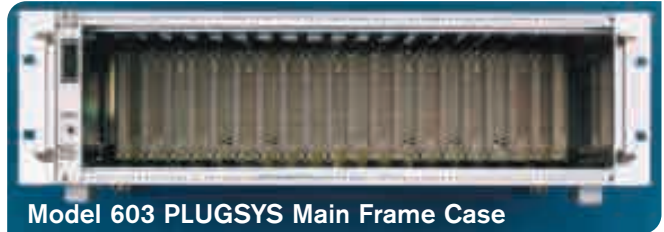
DAQ-PWL16P 77-0244 (United States) 73-4040 (International) ●●●●●

Data acquisition system and evaluation system
PowerLab

Choose this option when system configuration includes more than 8 measured parameters

Includes:

- 16 Channel PowerLab Hardware
- LabChart Pro Software



Model 603 PLUGSYS Main Frame Case



Two PLUGSYS Basic System Cases linked together with BLM

C-EX 73-4288 ●●●●●

PLUGSYS case expansion for additional 20 slot units

This option should be chosen when the number of amplifiers included in the options chosen exceed the base system case capacity of 20 slot units. Add up the number of slot units required by the base system and each chosen option in order to determine if you will require the case expansion.

Includes:

- PLUGSYS 603 Case
- Link Module for Connecting 2 603 Cases

Specialized Package Additions to All IH Physiology Systems: Temperature Measurement, Drug Addition, & More



IH-TEMP 73-4047 ●●●●●

Temperature measurement for all IH systems

Includes:

- Micro Thermocouple Probe
- Shielded Extension Cable
- Adapter Port
- TCAM Thermocouple Module
- Utilizes 2 Slot Units



IH-DAFLC 73-4042 ●●●●●

Flow-controlled drug addition (requires DAQ-HSE-IH Option)

This option allows a drug addition proportional to the measured flow in order to maintain a stable drug concentration at any flow rate.

Includes:

- Pump 11 Plus Advanced Syringe Pump
- Connection Tubing
- RS-232 Cable
- Controlling Software Option to ISOHEART

IH-RECIRC 73-4423 ●●●●●

Addition for filtration of recirculated perfusate

Includes:

- Inline Holder for disc particle filter, Diameter = 47 mm
- Polypropylene Particle Filter, 45 µm, Diameter = 47 mm

FOR CARDIOPLEGIA AND TEMPERATURE STUDIES

IH-CARDIOPLEGIA 73-4045 ●●●●●

Addition for cardioplegia

Includes:

- 0.5 Liter Reservoir for Cardioplegia Solution with Tube Set
- Additional Warming/Cooling Heat Exchanger
- Tubing and Stopcocks

LT-THERMO 73-2981 (115V) or 73-2481 (230V) ●●●●●

Low temperature thermocirculator

FEATURES & BENEFITS

- Environmentally friendly CFC-free, energy-saving automatic compressor
- -35 to 200°C Range, $\pm 0.02^\circ\text{C}$ control
- Low level and over-temperature alarms

Includes:

- 6 Liter Thermocirculator with Built-In Refrigerating System



IH-DAFLOW 73-4041 ●●●●●

Drug addition

Includes:

- Syringe Pump 11 Elite Programmable
- Connecting Tubing

Cardiomyocyte Isolation Systems

PSCI PERFUSION SYSTEM FOR CARDIOMYOCYTE ISOLATION

The PSCI is designed for pharmacology labs that require reproducible, high-yield viability for their cardiomyocyte assays. The PSCI has two separate perfusion pathways in order to separate clearing buffer from collagenase such that the solutions mix in less than 500 μ l, with a simple switch between the two. All solutions recirculate to the aerated reservoir so that they are fresh at all times. The wetted path is compatible with ethanol allowing for a sterile preparation. The system perfusate volume is < 3 ml for the mouse version and <5 ml for the rat/guinea pig version.

SEE PAGES 62-65



EASY CELL BASIC CARDIOMYOCYTE ISOLATION SYSTEM

The Easy Cell Basic system for use with mouse through guinea pig has a single perfusion pathway that is fully compatible with ethanol for disinfection. The transition from clearing buffer to collagenase is accomplished by either moving the suction tube or turning a stopcock. This system is recommended for basic research or student labs.

SEE PAGES 66-67



PSCI: Perfusion System for Cell Isolation



PERFUSION HUB

- Solid State Perfusion Circuit Ensures Thermal Stability, Laminar Flow, and Minimal System Volume
- Bubble Traps for Each Perfusate Stream Protect Heart from the Possibility of Air Emboli, Maximizing Cell Yield by Minimizing Regional Ischemia

PRECISION-MILLED CHANGEOVER STOPCOCK

- Integrated Stopcock with Independent, Non-Overlapping Fluid Paths for Minimal Mixing of Clearing Buffer and Enzymatic Buffers
- 3 Stopcock Positions for: Recirculation of Both Perfusates, Clearing Buffer Delivery with Recirculation of Collagenase, and Collagenase Delivery with Recirculation of Clearing Buffer

ENCLOSED HEART CHAMBER

- Heart Chamber Lid Integrated into the Base of the Perfusion Hub for Superior Temperature Control and to Isolate Heart from Contamination
- Low-Flow Gas Inlet Ensures Positive Pressure Within the Heart Chamber, Protecting Against Ingress of Bacteria

DUAL HEAT EXCHANGER

- Thin-Walled Stainless Steel Heat Exchanger Provides Quick Heating with Minimal Volume
- Interchangeable Insert Allows Switchover Between Mouse and Rat Heat Exchangers to Optimize Priming Volumes for the Two Species

COLLAGENASE RESERVOIR

- Custom Designed Small Volume (100 mL) Reservoir With Positive Pressure Gas Supply to Maintain Sterility of Collagenase
- Fully Autoclavable Components
- Dedicated Return Lines for Recirculating Unused Perfusate from Hub and for Recirculating Used Perfusate and Capturing Released Cardiomyocytes
- Place Digested Heart in Remainder of Perfusate, Dissect the LV and Disassociate all in the Reservoir

FEATURES & BENEFITS

- Dual Perfusion System for Blood Cell Flushing and Enzymatic Digestion
- Compatible with Disinfection using Ethanol
- Low Priming Volume Conserves Collagenase and Minimizes Temperature Loss Through Tubing (< 3 mL for Mouse System, < 5 mL for Rat System)
- Positive Pressure Gas Flow in Heart Chamber and Reservoir Prevents Bacterial Contamination
- Integrated Platform for Roller Pump Minimizes system footprint and conserves bench space
- Multi-Purpose System can be Fitted For Use With Other Organs (e.g. *In Situ* or *Ex Vivo* Hepatocyte Isolation from Rat or Mouse Liver)

PSCI: Perfusion System



FEATURES & BENEFITS

- Dual perfusion system for blood cell flushing and enzymatic digestion
- Compatible with disinfection using ethanol
- Positive pressure gas flow in heart chamber and reservoir prevent bacterial contamination
- Low priming volume conserves collagenase and minimizes temperature loss through tubing (< 3 ml for mouse system, < 5 mL for rat system)
- Integrated platform for roller pump minimizes system footprint and conserves use bench space
- Multi-purpose system can be fitted for use with other organs (e.g. *in situ* or *ex vivo* hepatocyte isolation from rat or mouse liver)

PERFUSION SYSTEM FOR CELL ISOLATION OF RAT, GUINEA PIG OR MOUSE CARDIOMYOCYTES

The PSCI is specifically designed for harvesting individual cells from isolated organs like mouse, rat or guinea pig hearts, liver and other organs. Here we include systems specifically packaged for cardiomyocyte isolation; however, feel free to contact our technical team if you would also like to use your system with other organs.

The PSCI works such that individual cells are released from the cell structure of the tissue through perfusion with enzyme solution and are then flushed out. Those cardiomyocytes are

collected in the collagenase reservoir to which the dissected left ventricle is added for further dissociation, allowing an increased total cell yield.

The apparatus is so designed that the individual steps required for preparing the cells can proceed as simply and clearly as possible. With two separate perfusion circuits, the organ can be switched between clearing buffer for removal of blood cells and collagenase buffer for organ digestion by means of a custom, precision-milled changeover stopcock.

Using the standard configuration, perfusion takes place under constant-flow conditions which are set by the researcher on the included peristaltic pump. The limits of the apparatus are a flow rate of about 50 or 100 ml/min depending on the configuration (mouse vs. rat/guinea pig). Common additions to the PSCI include perfusion pressure measurement and constant pressure perfusion. These options allow for optimized perfusion of the heart, further maximizing cell yield and viability by ensuring non-damaging physiological perfusion conditions.

The components wetted by the perfusion solutions are made from alcohol-resistant materials so that the apparatus can be filled with ethanol for sterilization/disinfection should your experiment require prolonged incubation time where bacterial contamination would be problematic.

The complete system includes everything required for simple cardiomyocyte isolation. For detailed descriptions of system extensions and options see page 65. Contact our expert technical team if you need assistance with system configuration, application support or custom design requests.

MEASURED SIGNALS & CALCULATED PARAMETERS ON A BIVENTRICULAR WORKING HEART SYSTEM:

The following signals can be monitored with the relevant optional packages:

- Perfusion Pressure
- Coronary Flow

PSCI: Core Systems and Options

PSCI-MH 73-4424 (115V) or 73-4425 (230V) ●●●●●

Core system PSCI for mouse cardiomyocyte isolation

Includes:

- PSCI-MH Base System for mouse heart
- Thermocirculator
- Analog Roller Pump and Tubing (Tygon)
- Aortic Cannula for mouse heart, 1.0 mm
- Protease Reservoir
- Mini Magnetic Stirrer
- Holder for Pressure Transducer
- 0.5 L Jacketed Buffer Reservoir and Tube Set

PSCI-RH 73-4426 (115V) or 73-4427 (230V) ●●●●●

Core system PSCI for rat or guinea pig cardiomyocyte isolation

Includes:

- PSCI-RH Base System for rat/guinea pig heart
- Thermocirculator
- Analog Roller Pump and Tubing (Tygon)
- Aortic Cannulae for rat and guinea pig hearts
 - 2.0 mm OD
 - 2.5 mm OD
 - 3.0 mm OD
- Protease Reservoir
- Mini Magnetic Stirrer
- Holder for Pressure Transducer
- 1.0 L Jacketed Buffer Reservoir and Tube Set

PSCI-PP 73-4428 ●●●●●

Addition for perfusion pressure measurement to PSCI

Includes:

- PLUGSYS Minicase
- TAM-D Transducer Amplifier Module
- Pressure Transducer

PSCI-CPP 73-2806 ●●●●●

Addition for constant pressure perfusion to PSCI

Choose this option if you require the ability to perfuse a heart in constant pressure mode. This option requires option PSCI-PP (IH2 73-4428) pressure measurement

- Allows operation in constant pressure or constant flow with simple switch
- Additional Measured Signals

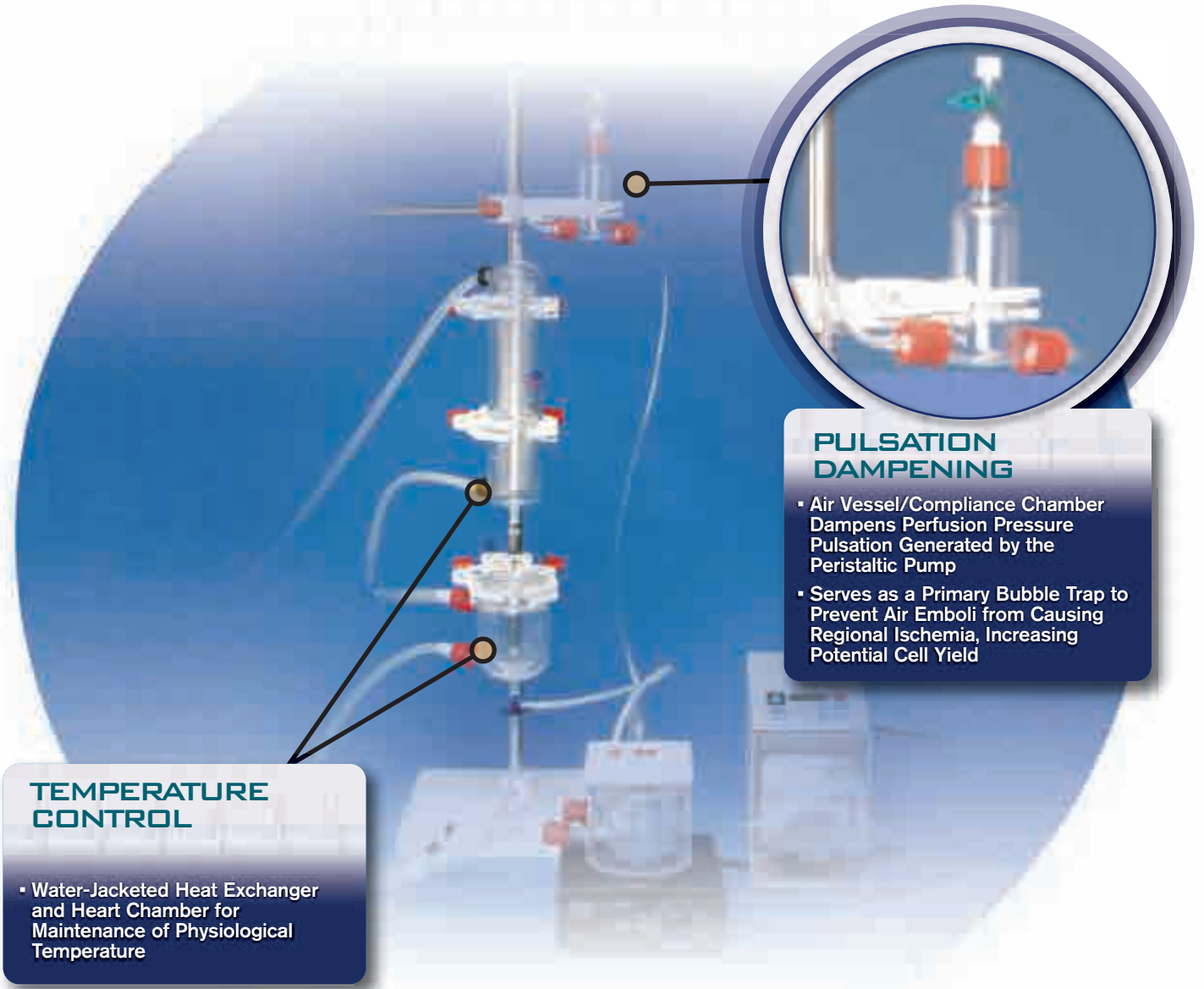
FEATURES & BENEFITS

- Accurate control of perfusion pressure or flow, even at very low flow rates
- Flexible perfusion circuit setup adjusts to suit individual perfusion conditions
 - Indirect coronary flow monitoring

Includes:

- SCP Servo Controlled Perfusion Module & Pump Connection Cable

Easy Cell: Simple System for Cell Extraction



PULSATION DAMPENING

- Air Vessel/Compliance Chamber Dampens Perfusion Pressure Pulsation Generated by the Peristaltic Pump
- Serves as a Primary Bubble Trap to Prevent Air Emboli from Causing Regional Ischemia, Increasing Potential Cell Yield

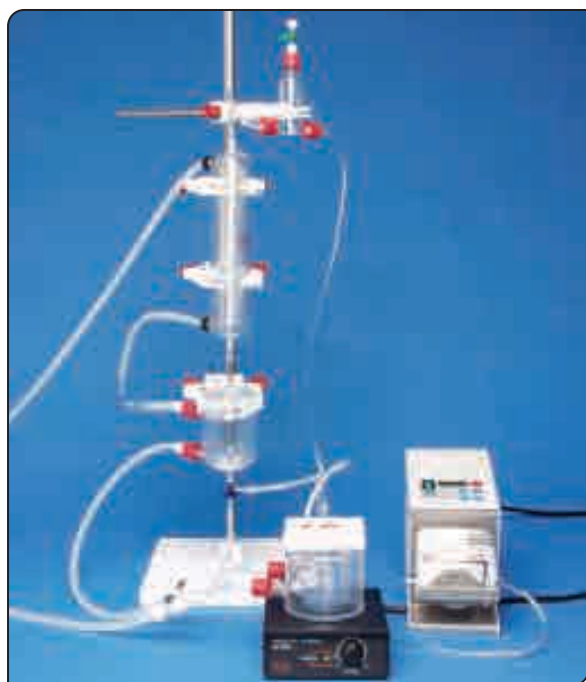
TEMPERATURE CONTROL

- Water-Jacketed Heat Exchanger and Heart Chamber for Maintenance of Physiological Temperature

FEATURES & BENEFITS

- Designed for Cardiomyocyte Isolation from Small Rodent Hearts
- Can be Adapted for Other Small Rodent Organs *In Situ* or *Ex Vivo*
- Simple Constant Flow Perfusion System
- Easy to Set Up, Operate, and Maintain
- Wetted Parts can be Disinfected with 70% Ethanol or Autoclaved for Sterilization

EasyCell System for Cardiomyocyte Isolation



FEATURES & BENEFITS

- Designed for cardiomyocyte isolation from small rodent hearts
- Can be adapted for other small rodent organs *in situ* or *ex vivo*
- Simple constant flow perfusion system
- Easy to set Up, operate, and maintain
- Wetted parts can be disinfected with 70% ethanol or autoclaved for sterilization

BASIC SYSTEM FOR CARDIOMYOCYTE ISOLATION IN MOUSE, RAT AND GUINEA PIG HEARTS

This perfusion system has been specifically created to meet the needs of individuals who wish to isolate primary cells from hearts of species in the size range of mouse to guinea pigs. The system can also be configured for either *in situ* or *ex vivo* organ perfusion with the addition of an operating table or moist chamber and appropriate cannulae.

The EasyCell System is simple to setup, operate and maintain and its compact design has a minimal footprint, conserving valuable bench space. The heart is first perfused

with a warmed, aerated standard perfusion buffer for blanching/clearing the heart of blood and then with a warmed, aerated protease solution for tissue disintegration. Unlike the PSCI system, the clearing buffer and collagenase share the same perfusion line, slightly delaying the delivery of the collagenase after switching over from the clearing buffer. The wetted components of the perfusion circuit can be flushed with a 70% ethanol solution or autoclaved for sterilization purposes should the cells need to be incubated for a number of hours following isolation rather than for immediate use.

The system is supplied complete with everything you need for basic cardiomyocyte isolation. Perfusion pressure monitoring can easily be added to aid in choosing an appropriate, physiological perfusion pump flow setting.

EASYCELL-CM 73-4430 (115V) 73-4431 (230V) ●●●●●

Basic constant flow cardiomyocyte isolation system for small rodents

Includes:

- EasyCell System Base and Glassware
- 100 ml Jacketed Protease Reservoir
- 1 L Jacketed Buffer Reservoir with Tube Set
- Aortic Cannula Set
 - 1.0 mm OD mouse cannula
 - 2.0 mm OD rat cannula
 - 3.0 mm OD guinea pig cannula
- Thermocirculator
- Digital Peristaltic Pump
- Mini Magnetic Stirrer
- Perfusion Pressure MLT-MLT Adapter



EASYCELL-PP 72-4496 (115V) 72-4497 (230V) ●●●●●

Research grade blood pressure transducer

System Accessories

BARBED CONNECTOR, LUER AND STOPCOCK KITS

A staple for all labs, these kits allow you to customize or expand the functionality and species range of your perfusion system. Many researchers add a compound of interest to a second or even a third reservoir rather than use a syringe pump for drug addition. Also common is the use of the system for multiple species, which requires that different tube sets be adapted to the existing tubing. The connectors and stopcocks required to accomplish this expansion are not included with base systems.

Small Kit



Medium Kit



Barbed Tubing Connector Kits

ORDER #	PRODUCT	TUBE ID	MATERIAL
IH2 72-1410 Small Polypropylene Barbed Connector Kit			
KIT COMPONENTS:			
IH2 72-1499	Barbed Connector	1/16 to 1/16 in	Polypropylene
IH2 72-1500	Barbed Connector	3/32 to 3/32 in	Polypropylene
IH2 72-1501	Barbed Connector	1/8 to 1/8 in	Polypropylene
IH2 72-1502	Barbed Connector	1/16 to 3/32 in	Polypropylene
IH2 72-1503	Barbed Connector	1/16 to 1/8 in	Polypropylene
IH2 72-1504	Barbed Connector	3/32 to 1/8 in	Polypropylene
IH2 72-1505	L Barbed Connector	1/16 to 1/16 in	Polypropylene
IH2 72-1506	L Barbed Connector	3/32 to 3/32 in	Polypropylene
IH2 72-1507	L Barbed Connector	1/8 to 1/8 in	Polypropylene
IH2 72-1508	L Barbed Connector	1/16 to 3/32 in	Polypropylene
IH2 72-1509	L Barbed Connector	1/16 to 1/8 in	Polypropylene
IH2 72-1510	L Barbed Connector	3/32 to 1/8 in	Polypropylene
IH2 72-1511	T Barbed Connector	1/16 to 1/16 in	Polypropylene
IH2 72-1512	T Barbed Connector	3/32 to 3/32 in	Polypropylene
IH2 72-1513	T Barbed Connector	1/8 to 1/8 in	Polypropylene
IH2 72-1514	T Barbed Connector	1/16 to 3/32 in	Polypropylene
IH2 72-1515	T Barbed Connector	1/16 to 1/8 in	Polypropylene
IH2 72-1516	T Barbed Connector	3/32 to 1/8 in	Polypropylene
IH2 72-1517	Y Barbed Connector	1/16 to 1/16 in	Polypropylene
IH2 72-1518	Y Barbed Connector	3/32 to 3/32 in	Polypropylene
IH2 72-1519	Y Barbed Connector	1/8 to 1/8 in	Polypropylene
IH2 72-1520	Barbed PLUG Connector	1/16 in	Polypropylene
IH2 72-1521	Barbed PLUG Connector	3/32 in	Polypropylene
IH2 72-1522	Barbed PLUG Connector	1/8 in	Polypropylene
IH2 72-1413 Medium Polypropylene Barbed Connector Kit			
KIT COMPONENTS:			
IH2 72-1561	Barbed Connector	1/4 to 1/4 in	Polypropylene
IH2 72-1562	Barbed Connector	5/16 to 5/16 in	Polypropylene
IH2 72-1563	Barbed Connector	3/8 to 3/8 in	Polypropylene
IH2 72-1564	Barbed Connector	1/4 to 5/16 in	Polypropylene
IH2 72-1565	Barbed Connector	1/4 to 3/8 in	Polypropylene
IH2 72-1566	Barbed Connector	5/16 to 3/8 in	Polypropylene
IH2 72-1567	L Barbed Connector	1/4 to 1/4 in	Polypropylene
IH2 72-1568	L Barbed Connector	5/16 to 5/16 in	Polypropylene
IH2 72-1569	L Barbed Connector	3/8 to 3/8 in	Polypropylene
IH2 72-1570	T Barbed Connector	1/4 to 1/4 in	Polypropylene
IH2 72-1571	T Barbed Connector	5/16 to 5/16 in	Polypropylene
IH2 72-1572	T Barbed Connector	3/8 to 3/8 in	Polypropylene
IH2 72-1573	Y Barbed Connector	1/4 to 1/4 in	Polypropylene
IH2 72-1574	Y Barbed Connector	3/8 to 3/8 in	Polypropylene

System Accessories

Barbed Tubing Connector Kits (Continued)

ORDER #	PRODUCT	TUBE ID	MATERIAL
IH2 72-1416	Large Polypropylene Barbed Connector Kit		
KIT COMPONENTS:			
IH2 72-1597	Barbed Connector	1/2 to 1/2 in	Polypropylene
IH2 72-1598	Barbed Connector	5/8 to 5/8 in	Polypropylene
IH2 72-1599	L Barbed Connector	1/2 to 1/2 in	Polypropylene
IH2 72-1600	L Barbed Connector	5/8 to 5/8 in	Polypropylene
IH2 72-1601	T Barbed Connector	1/2 to 1/2 in	Polypropylene
IH2 72-1602	T Barbed Connector	5/8 to 5/8 in	Polypropylene
IH2 72-1603	Y Barbed Connector	1/2 to 5/8 in	Polypropylene
IH2 72-1604	Y Barbed Connector	1/2 to 1/2 in	Polypropylene



LUER STOPCOCK KIT

The Luer Stopcock Kit includes a collection of 1-, 3- and 4-way stopcocks. Fittings include MLL (male Luer lock), FLL (female Luer lock) and Male Luer Slip. Some stopcocks have high pressure capabilities. This kit is supplied in a convenient box. All kit components are also sold separately.

Luer Stopcock Kit

ORDER #	PRODUCT
IH2 72-1664	Luer Stopcock Kit
KIT COMPONENTS:	
IH2 72-8327	One Way Stopcock (200 psi), FLL/Male Luer Slip
IH2 72-2647	One Way Stopcock (500 psi), FLL/MLL (Non-Rotating)
IH2 72-2648	3-Way Stopcock (1050 psi), FLL/FLL/MLL (Rotating)
IH2 72-2649	3-Way Stopcock (200 psi), FLL/FLL/MLL (Non-Rotating)
IH2 72-2650	One Way Stopcock (1050 psi), FLL/MLL (Non-Rotating)
IH2 72-8326	One Way Stopcock (200 psi), FLL/MLL (Rotating)
IH2 72-8328	4-Way Stopcock, FLL/FLL/Male Luer Slip
IH2 72-2693	3-Way Stopcock (200 psi), FLL/FLL/Male Luer Slip
IH2 72-2654	4-Way Stopcock, FLL/FLL/MLL (Rotating)
IH2 72-2655	One Way Stopcock (1050 psi), FLL/MLL (Rotating)
IH2 72-2656	3-Way Stopcock, FLL/FLL/MLL (Rotating)
IH2 72-2657	One Way Stopcock (500 psi), FLL/MLL (Rotating)
IH2 72-2658	3-Way Stopcock (1050 psi), FLL/FLL/MLL (Non-Rotating)
IH2 72-2659	3-Way Stopcock, FLL/FLL/FLL
IH2 72-2660	3-Way Stopcock (500 psi), FLL/FLL/MLL (Non-Rotating)
IH2 72-2661	4-Way Stopcock, FLL/FLL/MLL (Rotating)
IH2 72-2662	3-Way Stopcock (200 psi), FLL/FLL/MLL (Rotating)
IH2 72-2663	One Way Stopcock, FLL/MLL (Rotating)
IH2 72-9473	3-Way Stopcock, FLL/FLL/MLL (Non-Rotating)

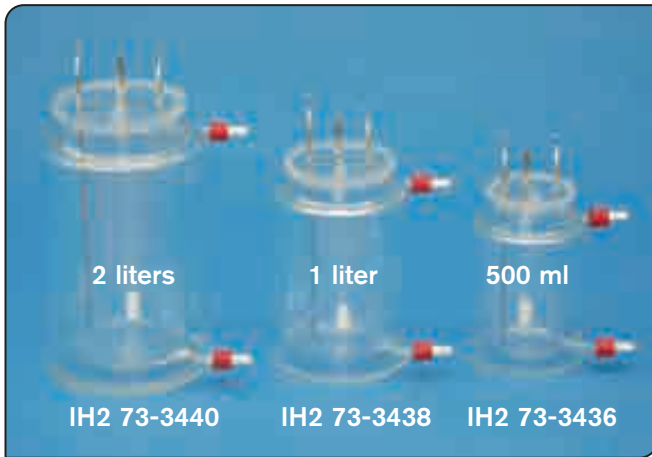
Luer to Tube Kits

ORDER #	PRODUCT	TUBE ID	MATERIAL
IH2 72-1406	White Nylon Luer Connector Kit		
KIT COMPONENTS:			
IH2 72-1418	Barbed Connector	FLL to 1/16 in	White Nylon
IH2 72-1419	Barbed Connector	FLL to 3/32 in	White Nylon
IH2 72-1420	Barbed Connector	FLL to 1/8 in	White Nylon
IH2 72-1421	Barbed Connector	FLL to 5/32 in	White Nylon
IH2 72-1422	Barbed Connector	FLL to 3/16 in	White Nylon
IH2 72-1423	Barbed Connector	FLL to 1/4 in	White Nylon
IH2 72-1424	Barbed Connector	FLL to 1/16 in	White Nylon
IH2 72-1425	Barbed Connector	FLL to 3/32 in	White Nylon
IH2 72-1426	Barbed Connector	FLL to 1/8 in	White Nylon
IH2 72-1427	Barbed Connector	FLL to 5/32 in	White Nylon
IH2 72-1428	Barbed Connector	FLL to 3/16 in	White Nylon
IH2 72-1429	Barbed Connector	FLL to 1/4 in	White Nylon
IH2 72-1430	Cap Connector	MLL	White Nylon
IH2 72-1431	Cap Connector	FLL	White Nylon
IH2 72-2735	Coupler with Threaded FLL Connection	FLL to MLL	White Nylon
IH2 72-1433	Connector	MLT to MLT	White Nylon
IH2 72-1434	Connector	FLL to FLL	White Nylon
IH2 72-1435	Elbow Connector	FLL to FLL	White Nylon
IH2 72-1436	T Connector	3-Way FLL	White Nylon

IH2 72-2739 Polypropylene Male Luer Taper Kit

KIT COMPONENTS:			
IH2 72-2731	Snap Luer Lock Ring	Male	Red Nylon
IH2 72-2732	Snap Luer Lock Ring	Male	Green Nylon
IH2 72-2733	Snap Luer Lock Ring	Male	Polypropylene
IH2 72-2707	Barbed Connector	MLT to 1/16 in	Polypropylene
IH2 72-2708	Barbed Connector	MLT to 3/32 in	Polypropylene
IH2 72-2742	Luer Coupler	Male	Polypropylene
IH2 72-2709	Barbed Connector	MLT to 1/8 in	Polypropylene
IH2 72-2710	Barbed Connector	MLT to 5/32 in	Polypropylene
IH2 72-2711	Barbed Connector	MLT to 3/16 in	Polypropylene
IH2 72-2712	Barbed Connector	MLT to 1/4 in	Polypropylene
IH2 72-2713	Barbed Connector	MLT to 1/16 in	Polypropylene
IH2 72-2748	T-Connector	FLL/MLT/MLT	Polypropylene
IH2 72-2714	Barbed Connector	MLT to 3/32 in	Polypropylene
IH2 72-2715	Barbed Connector	MLT to 1/8 in	Polypropylene
IH2 72-2716	Barbed Connector	MLT to 5/32 in	Polypropylene
IH2 72-2717	Barbed Connector	MLT to 3/16 in	Polypropylene
IH2 72-2718	Barbed Connector	MLT to 1/4 in	Polypropylene
IH2 72-2745	T-Connector	FLL/MLT/FLL	Polypropylene

System Accessories



WATER-JACKETED BUFFER RESERVOIRS

Whether you are adding additional reservoirs for drug addition or for increasing buffer capacity, our water-jacketed buffer reservoirs can be purchased separately. Note: For each reservoir you add, you will require a tube set for incorporation of the reservoir(s) into the thermostatic circuit unless it is the 6 L Reservoir.

Buffer Reservoir

ORDER #	PRODUCT
IH2 73-3440	2 Liter Jacketed Buffer Reservoir Jacketed
IH2 73-3438	1 Liter Jacketed Buffer Reservoir
IH2 73-3436	0.5 Liter Jacketed Buffer Reservoir
IH2 73-3496	100 ml Jacketed Buffer Reservoir
IH2 73-0322	6 Liter Reservoir Jacketed for Buffer Solution with tube set for thermostating circuit and fluid line shutoff valves
IH2 73-3456	Tube Set for Jacketed Buffer Reservoir with Fluid Line Shutoff Valves

Surgical Kits

RAT/GUINEA PIG ISOLATED HEART SURGICAL KIT

Rat/Guinea Pig Isolated Heart Surgical Kit

ORDER #	PRODUCT
IH2 72-8998	Rat/Guinea Pig Isolated Heart Surgical Kit
KIT COMPONENTS:	
IH2 51-7698	Suture without Needle, Silk Black Braid, 4-0, 100 yards
IH2 72-8402	Operating Scissors, 13.0 cm, Sharp/Sharp, Straight
IH2 72-2648	3-Way Stopcock (1050 psi), FLL/FLL/MLL (Rotating)
IH2 72-8949	Dressing Forceps, 13.0 cm, Straight, Slender
IH2 72-8497	Castroviejo-Mini Eye Scissors Spring Action, 11.0 cm, Right Angled
IH2 72-8614	Graefe Iris Forceps, Serrated, 10.0 cm, Strongly Curved, Points 0.3 mm, pkg. of 2
IH2 72-8973	HALSTEAD-MOSQUITO, Hemostatic Forceps, 12.5 cm, Straight, pkg. of 2
IH2 72-8817	Diethrich Mini Bulldog Clamp, 50 mm, Jaws 8 mm, Pressure 50 g, Straight



ISOLATED HEART PERFUSION SYSTEM

MOUSE ISOLATED HEART SURGICAL KIT

Mouse Isolated Heart Surgical Kit

ORDER #	PRODUCT
IH2 72-8999	Mouse Isolated Heart Surgical Kit
KIT COMPONENTS:	
IH2 51-7680	Suture without Needle, Silk Black Braid, 5-0, 100 yards
IH2 72-8591	Graefe Iris Forceps, Serrated, 10.0 cm, Straight, Points 0.7 mm
IH2 72-8440	Eye Scissors, 11.5 cm, Straight, Special Cut
IH2 72-8688	Jeweler's Forceps, 11.0 cm, No. 5, Angled, pkg. of 2
IH2 61-0196	Micro Vascular Clip for 1 to 2 mm Diameter Vessels, Occlusion Pressure 35 to 40 g, 11 mm long
IH2 72-8508	Vannas Eye Scissors, Spring Action Model Tübingen, 8.5 cm, Straight*



**Note: The Tübingen model has a longer blade than the standard Vannas scissors.*

Aortic Cannulae



AORTIC CANNULAE TO IH-SR SYSTEM

These special cannulae were designed for cannulating isolated heart to mount specifically on the IH-SR System, see pages 14-23.

Aortic Cannulae to IH-SR System

ORDER #	PRODUCT
IH2 73-2816	Aortic Cannula to IH-SR, OD 1.0 mm
IH2 73-2857	Aortic Cannula to IH-SR, OD 1.3 mm
IH2 73-2858	Aortic Cannula to IH-SR, OD 1.5 mm
IH2 73-2859	Aortic Cannula to IH-SR, OD 1.8 mm
IH2 73-2860	Aortic Cannula to IH-SR, OD 2.0 mm
IH2 73-2814	Aortic Cannula to IH-SR, OD 2.3 mm
IH2 73-2861	Aortic Cannula to IH-SR, OD 2.5 mm
IH2 73-2862	Aortic Cannula to IH-SR, OD 3.0 mm

NOTE IH-SR Cannulae are not compatible with Luer fittings. ●●●●●

AORTIC CANNULAE TO IH-5 & IH5-BI SYSTEM

These special cannulae were designed for cannulating isolated heart to mount specifically on the IH-5 System, see pages 24-35.

Aortic Cannulae to IH-5 System

ORDER #	PRODUCT
IH2 73-3065	Aortic Cannula to IH-5, OD 2.0 mm
IH2 73-2875	Aortic Cannula to IH-5, OD 2.5 mm
IH2 73-2876	Aortic Cannula to IH-5, OD 3.0 mm
IH2 73-2877	Aortic Cannula to IH-5, OD 3.5 mm
IH2 73-2878	Aortic Cannula to IH-5, OD 4.0 mm
IH2 73-2879	Aortic Cannula to IH-5, OD 5.0 mm
IH2 73-2880	Aortic Cannula to IH-5, OD 6.0 mm

NOTE IH-5/IH5-BI Cannulae are not compatible with other IH Systems. ●●●●●

AORTIC CANNULAE WITH LUER FITTING FOR USE WITH UP100-IH, PSCI, AND EASYCELL SYSTEMS

Aortic Cannulae with Luer Fitting

ORDER #	PRODUCT
IH2 73-0112	Set of 4 Aortic Metal Cannula with Luer Taper, 2.0, 2.5, 3.0, and 4.0 mm OD
IH2 73-2798	1.0 mm OD Aortic Metal Cannula with Luer Taper
IH2 73-2800	1.3 mm OD Aortic Metal Cannula with Luer Taper
IH2 73-2867	1.5 mm OD Aortic Metal Cannula with Luer Taper
IH2 73-3337	1.8 mm OD Aortic Metal Cannula with Luer Taper
IH2 73-2868	2.0 mm OD Aortic Metal Cannula with Luer Taper
IH2 73-2869	2.3 mm OD Aortic Metal Cannula with Luer Taper
IH2 73-2870	2.5 mm OD Aortic Metal Cannula with Luer Taper
IH2 73-2871	3.0 mm OD Aortic Metal Cannula with Luer Taper
IH2 73-2872	4.0 mm OD Aortic Metal Cannula with Luer Taper

System Accessories: Additional Tubing Connector Kits



Barbed Tubing Connector Kits

ORDER #	PRODUCT	TUBE ID	MATERIAL
IH2 72-1409	Small Black Nylon Barbed Connector Kit		
KIT COMPONENTS:			
IH2 72-1475	Barbed Connector	1/16 to 1/16 in	Black Nylon
IH2 72-1476	Barbed Connector	3/32 to 3/32 in	Black Nylon
IH2 72-1477	Barbed Connector	1/8 to 1/8 in	Black Nylon
IH2 72-1478	Barbed Connector	1/16 to 3/32 in	Black Nylon
IH2 72-1479	Barbed Connector	1/16 to 1/8 in	Black Nylon
IH2 72-1480	Barbed Connector	3/32 to 1/8 in	Black Nylon
IH2 72-1481	L Barbed Connector	1/16 to 1/16 in	Black Nylon
IH2 72-1482	L Barbed Connector	3/32 to 3/32 in	Black Nylon
IH2 72-1483	L Barbed Connector	1/8 to 1/8 in	Black Nylon
IH2 72-1486	L Barbed Connector	3/32 to 1/8 in	Black Nylon
IH2 72-1487	T Barbed Connector	1/16 to 1/16 in	Black Nylon
IH2 72-1488	T Barbed Connector	3/32 to 3/32 in	Black Nylon
IH2 72-1489	T Barbed Connector	1/8 to 1/8 in	Black Nylon
IH2 72-1491	T Barbed Connector	1/16 to 1/8 in	Black Nylon
IH2 72-1492	T Barbed Connector	3/32 to 1/8 in	Black Nylon
IH2 72-1493	Y Barbed Connector	1/16 to 1/16 in	Black Nylon
IH2 72-1494	Y Barbed Connector	3/32 to 3/32 in	Black Nylon
IH2 72-1495	Y Barbed Connector	1/8 to 1/8 in	Black Nylon
IH2 72-1498	Barbed PLUG Connector	1/8 in	Black Nylon

Barbed Tubing Connector Kits (Continued)

ORDER #	PRODUCT	TUBE ID	MATERIAL
IH2 72-1411	Small Kynar® Barbed Connector Kit		
KIT COMPONENTS:			
IH2 72-1523	Barbed Connector	1/16 to 1/16 in	Kynar®
IH2 72-1524	Barbed Connector	3/32 to 3/32 in	Kynar®
IH2 72-1525	Barbed Connector	1/8 to 1/8 in	Kynar®
IH2 72-1526	Barbed Connector	1/16 to 3/32 in	Kynar®
IH2 72-1527	Barbed Connector	1/16 to 1/8 in	Kynar®
IH2 72-1528	Barbed Connector	3/32 to 1/8 in	Kynar®
IH2 72-1530	L Barbed Connector	3/32 to 3/32 in	Kynar®
IH2 72-1531	L Barbed Connector	1/8 to 1/8 in	Kynar®
IH2 72-1533	L Barbed Connector	1/16 to 1/8 in	Kynar®
IH2 72-1535	T Barbed Connector	1/16 to 1/16 in	Kynar®
IH2 72-1536	T Barbed Connector	3/32 to 3/32 in	Kynar®
IH2 72-1537	T Barbed Connector	1/8 to 1/8 in	Kynar®
IH2 72-1539	T Barbed Connector	1/16 to 1/8 in	Kynar®
IH2 72-1540	T Barbed Connector	3/32 to 1/8 in	Kynar®
IH2 72-1541	Y Barbed Connector	1/16 to 1/16 in	Kynar®
IH2 72-1542	Y Barbed Connector	3/32 to 3/32 in	Kynar®
IH2 72-1543	Y Barbed Connector	1/8 to 1/8 in	Kynar®
IH2 72-1412	Medium Black Nylon Barbed Connector Kit		
KIT COMPONENTS:			
IH2 72-1547	Barbed Connector	1/4 to 1/4 in	Black Nylon
IH2 72-1548	Barbed Connector	5/16 to 5/16 in	Black Nylon
IH2 72-1549	Barbed Connector	3/8 to 3/8 in	Black Nylon
IH2 72-1550	Barbed Connector	1/4 to 5/16 in	Black Nylon
IH2 72-1551	Barbed Connector	1/4 to 3/8 in	Black Nylon
IH2 72-1552	Barbed Connector	5/16 to 3/8 in	Black Nylon
IH2 72-1553	L Barbed Connector	1/4 to 1/4 in	Black Nylon
IH2 72-1554	L Barbed Connector	5/16 to 5/16 in	Black Nylon
IH2 72-1555	L Barbed Connector	3/8 to 3/8 in	Black Nylon
IH2 72-1556	T Barbed Connector	1/4 to 1/4 in	Black Nylon
IH2 72-1557	T Barbed Connector	5/16 to 5/16 in	Black Nylon
IH2 72-1558	Y Barbed Connector	3/8 to 3/8 in	Black Nylon
IH2 72-1559	Y Barbed Connector	1/4 to 1/4 in	Black Nylon
IH2 72-1560	Y Barbed Connector	3/8 to 3/8 in	Black Nylon

Kynar® is a registered trademark of Arkema, Inc.

System Accessories: Additional Tubing Connector Kits

Barbed Tubing Connector Kits (Continued)

ORDER #	PRODUCT	TUBE ID	MATERIAL
IH2 72-1414	Medium Kynar® Barbed Connector Kit		
KIT COMPONENTS:			
IH2 72-1575	Barbed Connector	1/4 to 1/4 in	Kynar®
IH2 72-1576	Barbed Connector	5/16 to 5/16 in	Kynar®
IH2 72-1577	Barbed Connector	3/8 to 3/8 in	Kynar®
IH2 72-1578	Barbed Connector	1/4 to 5/16 in	Kynar®
IH2 72-1579	Barbed Connector	1/4 to 3/8 in	Kynar®
IH2 72-1580	Barbed Connector	5/16 to 3/8 in	Kynar®
IH2 72-1581	L Barbed Connector	1/4 to 1/4 in	Kynar®
IH2 72-1582	L Barbed Connector	5/16 to 5/16 in	Kynar®
IH2 72-1583	L Barbed Connector	3/8 to 3/8 in	Kynar®
IH2 72-1584	T Barbed Connector	1/4 to 1/4 in	Kynar®
IH2 72-1585	T Barbed Connector	5/16 to 5/16 in	Kynar®
IH2 72-1586	T Barbed Connector	3/8 to 3/8 in	Kynar®
IH2 72-1587	Y Barbed Connector	1/4 to 1/4 in	Kynar®
IH2 72-1588	Y Barbed Connector	3/8 to 3/8 in	Kynar®

Small Kit



Medium Kit



Barbed Tubing Connector Kits (Continued)

ORDER #	PRODUCT	TUBE ID	MATERIAL
IH2 72-1415	Large Black Nylon Barbed Connector Kit		
KIT COMPONENTS:			
IH2 72-1589	Barbed Connector	1/2 to 1/2 in	Black Nylon
IH2 72-1590	Barbed Connector	5/8 to 5/8 in	Black Nylon
IH2 72-1591	L Barbed Connector	1/2 to 1/2 in	Black Nylon
IH2 72-1592	L Barbed Connector	5/8 to 5/8 in	Black Nylon
IH2 72-1593	T Barbed Connector	1/2 to 1/2 in	Black Nylon
IH2 72-1594	T Barbed Connector	5/8 to 5/8 in	Black Nylon
IH2 72-1595	Y Barbed Connector	1/2 to 5/8 in	Black Nylon
IH2 72-1596	Y Barbed Connector	1/2 to 1/2 in	Black Nylon
IH2 72-1417	Large Kynar® Barbed Connector Kit		
KIT COMPONENTS:			
IH2 72-1605	Barbed Connector	1/2 to 1/2 in	Kynar®
IH2 72-1606	Barbed Connector	5/8 to 5/8 in	Kynar®
IH2 72-1607	L Barbed Connector	1/2 to 1/2 in	Kynar®
IH2 72-1608	L Barbed Connector	5/8 to 5/8 in	Kynar®
IH2 72-1609	T Barbed Connector	1/2 to 1/2 in	Kynar®
IH2 72-1610	T Barbed Connector	5/8 to 5/8 in	Kynar®
IH2 72-1611	Y Barbed Connector	1/2 to 5/8 in	Kynar®
IH2 72-1612	Y Barbed Connector	1/2 to 1/2 in	Kynar®

Large Kit



Kynar® is a registered trademark of Arkema, Inc.

System Accessories: Additional Tubing Connector Kits

Luer to Tube Kits

ORDER #	PRODUCT	TUBE ID	MATERIAL
IH2 72-2738	White Nylon Male Luer Taper Kit		
KIT COMPONENTS:			
IH2 72-2731	Snap Luer Lock Ring	Male	Red Nylon
IH2 72-2732	Snap Luer Lock Ring	Male	Green Nylon
IH2 72-2733	Snap Luer Lock Ring	Male	Polypropylene
IH2 72-2695	Barbed Connector	MLT to 1/16 in	White Nylon
IH2 72-2696	Barbed Connector	MLT to 3/32 in	White Nylon
IH2 72-2741	Luer Coupler	Male	White Nylon
IH2 72-2697	Barbed Connector	MLT to 1/8 in	White Nylon
IH2 72-2698	Barbed Connector	MLT to 5/32 in	White Nylon
IH2 72-2699	Barbed Connector	MLT to 3/16 in	White Nylon
IH2 72-2700	Barbed Connector	MLT to 1/4 in	White Nylon
IH2 72-2701	Barbed Connector	MLT to 1/16 in	White Nylon
IH2 72-2747	T-Connector	FLL/MLT/MLT	White Nylon
IH2 72-2702	Barbed Connector	MLT to 3/32 in	White Nylon
IH2 72-2703	Barbed Connector	MLT to 1/8 in	White Nylon
IH2 72-2704	Barbed Connector	MLT to 5/32 in	White Nylon
IH2 72-2705	Barbed Connector	MLT to 1/8 in	White Nylon
IH2 72-2706	Barbed Connector	MLT to 1/4 in	White Nylon
IH2 72-2744	T-Connector	FLL/MLT/FLL	White Nylon



Luer to Tube Kits (Continued)

ORDER #	PRODUCT	TUBE ID	MATERIAL
IH2 72-2740	Polycarbonate Male Luer Taper Kit		
KIT COMPONENTS:			
IH2 72-2731	Snap Luer Lock Ring	Male	Red Nylon
IH2 72-2732	Snap Luer Lock Ring	Male	Green Nylon
IH2 72-2734	Snap Luer Lock Ring	Male	Polycarbonate
IH2 72-2719	Barbed Connector	MLT to 1/16 in	Polycarbonate
IH2 72-2720	Barbed Connector	MLT to 3/32 in	Polycarbonate
IH2 72-2743	Luer Coupler	Male	Polycarbonate
IH2 72-2721	Barbed Connector	MLT to 1/8 in	Polycarbonate
IH2 72-2722	Barbed Connector	MLT to 5/32 in	Polycarbonate
IH2 72-2723	Barbed Connector	MLT to 3/16 in	Polycarbonate
IH2 72-2724	Barbed Connector	MLT to 1/4 in	Polycarbonate
IH2 72-2725	Barbed Connector	MLT to 1/16 in	Polycarbonate
IH2 72-2749	T-Connector	FLL/MLT/MLT	Polycarbonate
IH2 72-2726	Barbed Connector	MLT to 3/32 in	Polycarbonate
IH2 72-2727	Barbed Connector	MLT to 1/8 in	Polycarbonate
IH2 72-2728	Barbed Connector	MLT to 5/32 in	Polycarbonate
IH2 72-2729	Barbed Connector	MLT to 3/16 in	Polycarbonate
IH2 72-2730	Barbed Connector	MLT to 1/4 in	Polycarbonate
IH2 72-2746	T-Connector	FLL/MLT/FLL	Polycarbonate

Configure your ideal Isolated System

Please use the below checklist and system configuration tool to keep track of your custom system. Once you have all of the items you need, simply email a quotation request to sales@hugo-sachs.de.

Here are some basic questions to answer – this helps us help you:

Species:



☐ Mice ☐ Rats ☐ Guinea Pig ☐ Small Rabbit ☐ Rabbit

Look for the systems with the appropriate species logo displayed.

Perfusion Mode:

- ☐ Retrograde perfusion according to Langendorff: UP-100, IH-SR, IH-5
- ☐ Ejecting, Working Heart according to Neely (left heart only): IH-SR or IH-5 Only
- ☐ Ejecting, Biventricular Working Heart (right heart and left heart perfusion), IH5-BI
- ☐ Cardiomyocyte Isolation : IH-SR and UP-100 are myocyte isolation compatible. PSCI and EasyCell are dedicated myocyte isolation systems.

Perfusion Solutions:

(solutions are not provided by Harvard Apparatus) :

- ☐ Standard Krebs-Henseleit Buffer: no additional option required
- ☐ Buffer with Additive that may foam if bubbled: requires the Fiber Oxygenator Option for your chosen system
- ☐ Recirculating Perfusion Solution: requires particle filter option

Measurement System:

Langendorff System

- ☐ Monophasic Action Potential (MAP)
- ☐ Lead II ECG/EG (Single Lead)

Working Heart

- ☐ Pressure Catheter OR ☐ Pressure Volume Catheter
- ☐ Atrium Flow (Cardiac Output) ☐ Coronary Flow
- ☐ Preload (Diastolic) pressures > 11 cmH₂O: Gottlieb Valve Option

Temperature: ☐ Yes ☐ No

Electrophysiology:

- ☐ Multi-lead ECG (only on rat and larger hearts)
- ☐ 12-LEAD (6 Einthoven-Goldberger and 6 Wilson leads)
- ☐ 6-LEAD (6 Einthoven-Goldberger)
- ☐ Multi-Monophasic Action Potential (IH-5 System only).
Number of MAP Electrodes: _____ (up to 8)

Gas Concentrations:

☐ pO₂ ☐ pH ☐ pCO₂

Electrical Stimulation:

☐ Pacing

Data Acquisition:

☐ Need Data Acquisition ☐ Already have one



77

[illegible]

Contact your local Harvard Apparatus Office or Harvard Apparatus Authorized Distributor for a Quotation. If you do not have one or do not know who it is, please send the request to sales@hugo-sachs.de and we will ensure that you are assisted.

IH-SR Langendorff References (continued from page 23):

17. Reil JC, Hohl M, Kazakov A, Oberhofer M, Kaestner L, Mueller P, Adam O, Maack C, Lipp P, Mewis C, Allesie M, Laufs U, Böhm M, Neuberger HR, (2010). Cardiac Rac1 overexpression in mice creates a substrate for atrial arrhythmias characterized by structural remodelling. *Cardiovasc Res.*, 87(3):485-93.
18. Trask AJ, Averill DB, Ganten D, Chappell MC, Ferrario CM, (2007) Primary role of angiotensin-converting enzyme-2 in cardiac production of angiotensin-(1-7) in transgenic Ren-2 hypertensive rats. *Am J Physiol Heart Circ Physiol.*, 292(6):H3019-24.
19. Tokarska-Schlattner M, Zaugg M, da Silva R, Lucchinetti E, Schaub MC, Wallimann T, Schlattner U, (2005). Acute toxicity of doxorubicin on isolated perfused heart: response of kinases regulating energy supply. *Am J Physiol Heart Circ Physiol.*, 289(1):H37-47.
20. Wascher TC, Wölkart G, Russell JC, Brunner F, (2000). Delayed insulin transport across endothelium in insulin-resistant JCR:LA-cp rats. *Diabetes.*, 49(5):803-9.

IH-5 Working Heart References (continued from page 35):

5. Trescher K, Bauer M, Dietl W, Hallström S, Wick N, Wolfsberger M, Ullrich R, Jürgens G, Wolner E, Podesser BK, (2009). Improved myocardial protection in the failing heart by selective endothelin-A receptor blockade. *J Thorac Cardiovasc Surg.*, 137(4):1005-11, 1011e1.
6. Vogt S, Troitzsch D, Abdul-Khaliq H, Böttcher W, Lange PE, Moosdorf R, (2000). Improved myocardial preservation with short hyperthermia prior to cold cardioplegic ischemia in immature rabbit hearts. *Eur J Cardiothorac Surg.*, 18(2):233-40.
7. Vogt S, Troitzsch D, Abdul-Khaliq H, Moosdorf R, (2007). Heat stress attenuates ATP-depletion and pH-decrease during cardioplegic arrest. *J Surg Res.*, 139(2):176-81.
8. Wiedemann D, Schneeberger S, Friedl P, Zacharowski K, Wick N, Boesch F, Margreiter R, Laufer G, Petzelbauer P, Semsroth S, (2010). The fibrin-derived peptide Bbeta(15-42) significantly attenuates ischemia-reperfusion injury in a cardiac transplant model. *Transplantation*, 89(7):824-9.

Customer Support



Hugo Sachs Elektronik - Harvard Apparatus provides complete research solutions across all life science fields including: Behavioral Neuroscience, Cardiovascular and Respiratory Physiology, Tissue Engineering, Pharmacology and Toxicology. We provide researchers with a range of tools and equipment for virtually any application including: compound screening, drug infusion, microfluidics, PK-ADMET, high fidelity data acquisition and analysis, *in-vivo* monitoring and *ex-vivo* perfusion.

Hugo Sachs Elektronik - Harvard Apparatus is the best single source for research systems, equipment and support to keep your research moving at the pace of science.

For a custom configuration and full system quotation:

www.hugo-sachs.de/ihmail.html

In the United States:

physiology@harvardapparatus.com

Contact our technical experts at our sales subsidiaries or authorized distributors at:

www.hugo-sachs.de & www.harvardapparatus.com

HUGO SACHS ELEKTRONIK

The Physiology Specialists

HARVARD

A P P A R A T U S

84 October Hill Road

Holliston, MA 01746

phone: 508.893.8999

toll-free: 800.272.2775

fax: 508.429.5732

email: physiology@harvardapparatus.com

web: www.harvardapparatus.com,

www.hugo-sachs.de

Isolated Heart Perfusion Systems

for mouse to rabbit animal models

Myocyte Harvesting & Isolation • Cardiovascular Screening
Contractility Studies • Tissue Engineering • Refractory Period
Cardioplegia • Hemodynamics • Cardiac Mapping • Safety Pharmacology
Ischemia and Reperfusion • Phenotyping of Transgenics
Electrophysiology (ECG, MAP)

www.hugo-sachs.de • www.harvardapparatus.com