SUMMARY OF SAFETY AND EFFECTIVENESS DATA (SSED)

I. GENERAL INFORMATION

Device Generic Name:	Automated External Defibrillator
Device Trade Names:	LIFEPAK® 1000 Defibrillator LIFEPAK® 1000 Defibrillator Lithium-Ion Rechargeable Battery LIFEPAK® 1000 Defibrillator Non-Rechargeable Battery LIFEPAK® 20 Defibrillator/Monitor (Refurbished) LIFEPAK® 20e Defibrillator/Monitor LIFEPAK® 15 Monitor/Defibrillator LIFEPAK® Lithium-ion Rechargeable Battery (for use with the LIFEPAK 15 Monitor/Defibrillator)
Device Product Code:	MKJ
Applicant's Name and Address:	Physio-Control, Inc. 11811 Willows Road NE Redmond, WA 98052 USA
Date(s) of Panel Recommendation:	None
Premarketing Approval Application (PMA) Number:	P160026
Date of FDA Notice of Approval:	July 2, 2018

The LIFEPAK 1000, LIFEPAK 20/20e, and LIFEPAK 15 models, with respective batteries, have been commercially available since their initial clearance under respective 510(k) submissions as summarized in the Marketing History section below.

P160026 has been submitted in response to the Final Order issued January 29, 2015 in the Federal Register Volume 80 Number 19, Docket No. FDA-2013 – N 0234 and republished February 3, 2015, in the Federal Register Volume 80 Number 22, Docket No. FDA-2013-N-0234. The Final Order required premarket approval of marketed pre-amendment Class III Automated External Defibrillators (AEDs), product code MKJ. Products affected by this Order are the LIFEPAK 1000 defibrillator, LIFEPAK 20e defibrillator/monitor, LIFEPAK 20 defibrillator/monitor, and LIFEPAK 15 defibrillator/monitor that can be used as an AED, but also have other capabilities (e.g., monitoring functions, manual defibrillation, etc.). A combination of postmarket experience data, relevant literature, clinical data, animal testing, and in-vitro bench testing has been reviewed to demonstrate a reasonable assurance of safety and effectiveness for the LIFEPAK devices.

II. INDICATIONS FOR USE

LIFEPAK 1000:

The defibrillator is to be used in AED mode only on patients who are in cardiopulmonary

arrest. The patient must be unresponsive, not breathing normally, and showing no signs of circulation.

The defibrillator may be used with QUIK-COMBO ® Electrodes with REDI-PAK™ Preconnect System only on adults and children who are 8 years old or more or who weigh more than 25 kg (55 lbs). The defibrillator may be used on children who are less than 8 years old or weigh less than 25 kg (55 lbs.) with Infant/Child Reduced Energy Defibrillation Electrodes.

LIFEPAK 20e and LIFEPAK 20:
The AED mode is to be used only on patients in cardiopulmonary arrest. The patient must be unconscious, pulseless, and not breathing normally before using the defibrillator to analyze the patient's ECG rhythm.

In AED mode, the LIFEPAK 20 and LIFEPAK 20e defibrillator/monitor is not intended for use on pediatric patients less than 8 years old.

LIFEPAK 15:
AED mode is to be used only on patients in cardiopulmonary arrest. The patient must be unconscious, pulseless, and not breathing normally before using the defibrillator to analyze the patient's ECG rhythm. In AED mode, the LIFEPAK 15 monitor/defibrillator is not intended for use on pediatric patients less than 8 years old.

III. CONTRAINDICATIONS

Contraindications for the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 models are specified in the Operating Instructions (labeling) for each LIFEPAK model, depending upon the device's defibrillation and/or monitoring capabilities. Contraindications related to manual defibrillation and monitoring functions applicable to the LIFEPAK models.

With respect to use as an AED, the LIFEPAK 1000, LIFEPAK 20, LIFEPAK 20e and LIFEPAK 15 models have no known contraindications.

IV. WARNINGS AND PRECAUTIONS

The warnings and precautions can be found in the Operating Instructions (labeling) of the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15.

V. DEVICE DESCRIPTION

The LIFEPAK 1000 is a semiautomatic defibrillator with optional manual mode and ECG display, while the LIFEPAK 20, LIFEPAK 20e, and LIFEPAK 15 are defibrillator/monitors that can be used as an AED, but also have other capabilities (e.g., monitoring functions, manual defibrillation, etc.). The AED functions of these LIFEPAK devices are indicated for use by trained professional responders to treat victims of sudden cardiac arrest.

- ***Principal of Operation:*** Sudden cardiac arrest is usually caused by a malfunction in the heart's electrical system. Called ventricular fibrillation, this critical condition prevents the heart from pumping blood throughout the body. Ventricular fibrillation can cause death within seconds.

  Defibrillation is a relatively simple procedure that involves placing electrode pads or paddles on a victim's exposed chest and delivering an electrical shock to the heart. The externally-delivered shock often restores the heart's electrical system to a normal rhythm. Combined with cardiopulmonary resuscitation (CPR), defibrillation provides the most effective care for victims in cardiac arrest.

  Shock Advisory System (SAS): The Physio-Control patented Shock Advisory System is an electrocardiogram (ECG) analysis system built into the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 devices that advises the operator if the algorithm detects a shockable or non-shockable ECG rhythm. The SAS acquires ECG via therapy electrodes only.

- ***Device Descriptions and Use:*** Brief descriptions of the devices are as follows. For visual reference, diagrams of the devices are also provided. Additional diagrams and pictures of the devices can be found in the LIFEPAK Operating Instructions (labeling) for each device.

  - ***LIFEPAK 1000*** - The LIFEPAK 1000 defibrillator (Figure 1) is a semiautomatic defibrillator with optional manual mode and ECG display. It is indicated for use by personnel who are authorized by a physician/medical director and are trained in CPR and the use of the LIFEPAK 1000 defibrillator. Refurbished LIFEPAK 1000 devices are also available for distribution.

    The LIFEPAK 1000 defibrillator can be operated in either of three (3) modes: AED mode (automated external defibrillation), Manual mode (operator ECG interpretation, operator control of charge and shock functions), and ECG mode (ECG display allows for rhythm and heart rate monitoring).

Figure 1: LIFEPAK 1000 AED

- ***LIFEPAK 20e and LIFEPAK 20*** - The LIFEPAK 20e and LIFEPAK 20 defibrillator/monitors (LIFEPAK 20e - Figure 2) are acute cardiac care response systems which were developed for hospitals and clinics for use on "crash carts," as well as portable emergency response throughout a hospital. The LIFEPAK 20e and LIFEPAK 20 defibrillator/monitors are indicated to be used by authorized healthcare providers.
  The LIFEPAK 20e defibrillator/monitor is a modified version of the LIFEPAK 20 defibrillator/monitor and includes a lithium-ion internal battery (instead of a nickel-metal hydride internal battery) and a battery status indicator on the device screen. The LIFEPAK 20 is no longer manufactured for distribution in the US, but existing devices in commercial use and refurbished devices are available for distribution.

  The LIFEPAK 20e and LIFEPAK 20 defibrillator/monitors include manual and automated external defibrillation, noninvasive pacing, ECG monitoring (3-wire or 5-wire), pulse oximetry monitoring and synchronized cardioversion. When used with the optional CodeManagement Module™ (CMM) accessory, wireless data transmission (via the CMM) and CO_2 monitoring are also available.

Figure 2: Picture of LIFEPAK 20e Defibrillator/Monitor in AED Mode (with door closed)

- ***LIFEPAK 15*** - The LIFEPAK 15 monitor/defibrillator (Figure 3) is a complete acute cardiac care response system designed for basic life support (BLS) and advanced life support (ALS) patient management protocols. The LIFEPAK 15 monitor/defibrillator is indicated for use by trained medical personnel, such as professional emergency medical services (EMS) personnel. Service is provided for existing LIFEPAK 15 devices in commercial use and refurbished devices are available for distribution. The LIFEPAK 15 monitor/defibrillator includes many standard and optional features. The standard features of the LIFEPAK 15 include:

  - Automated External Defibrillation
  - Manual Defibrillation
  - Synchronized Cardioversion
  - Noninvasive Pacing
  - ECG Monitoring

  The optional features of the LIFEPAK 15 include:

  - 12-Lead Electrocardiography
  - Pulse Oximetry (SpO_2, SpCO, and SpMet Monitoring)
  - Noninvasive Blood Pressure (NIBP) Monitoring
  - CO_2 Monitoring
  - Invasive Pressure Monitoring
  - Temperature Monitoring
  - Vital Sign and ST Segment Trends

  Figure 3: LIFEPAK 15 Monitor/Defibrillator

- ***Device Features:*** In addition to the device capabilities listed in the above *Device Descriptions* for each specific LIFEPAK model, a summary of the main features of the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 devices is listed below.
    - AED, Manual Defibrillation and/or ECG modes
    - Biphasic truncated exponential (BTE) defibrillation waveform
    - Multiple configurable AED defibrillation shock energy levels from 150 to 360 joules
    - Manual defibrillation (LIFEPAK models 20e, LIFEPAK 20 and 15) - defibrillation shock energy levels from 2 to 360 joules
    - ECG Display (optional in LIFEPAK 1000)
    - cprMAX™ Technology – allows resuscitation protocols to maximize the amount of CPR delivered during device use
    - CPR Metronome (LIFEPAK models 20e, LIFEPAK 20 and 15)
    - Nonrechargeable or rechargeable batteries
    - Power On, Automatic or User-initiated Self-Tests - to assess device readiness for use
    - Data Management - for capture of ECG/event data

VI. ALTERNATIVE PRACTICES AND PROCEDURES

Defibrillation is the only currently available treatment for termination of ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT).

VII. MARKETING HISTORY

The LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 devices were FDA-reviewed under 510(k) Notifications. The Original 510(k) clearances for each LIFEPAK model are as noted in Table 1. As noted, all devices have been in U.S. commercial use for many years.

The devices have also been shipped and used commercially since obtaining regulatory clearances/approvals in numerous countries, other than the United States. Current commercialization of each LIFEPAK model is also noted in Table 1.

Table 1: LIFEPAK models - 510(k) Clearances and Commercialization

Model	***Original 510(k) clearance***	***Current commercialization***
LIFEPAK 1000	K042404; cleared 12/22/2005	in 29 different countries for ~10 years (since 2006)
LIFEPAK 20	K012274; cleared 2/5/2002	in 11 different countries for ~14 years (since 2002)
LIFEPAK 20e	K073089; cleared 7/29/2008	in 26 different countries for ~8 years (since 2008)
LIFEPAK 15	K082937; cleared 3/11/2009	in 25 different countries for ~7.5 years (since late 2008)

None of the above LIFEPAK devices have been withdrawn from marketing in the United States or any foreign country.

VIII. PROBABLE ADVERSE EFFECTS OF THE DEVICE ON HEALTH

Below is a list of the potential adverse effects (e.g., complications) associated with the use of the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 models.

- Failure to identify shockable arrhythmia;
- Failure to deliver a defibrillation shock in the presence of VF or pulseless VT, which may result in death or permanent injury;
- Inappropriate energy delivery which could cause failed defibrillation or post-shock dysfunction;
- Myocardial damage;
- Fire hazard in the presence of high oxygen concentration or flammable anesthetic agents;
- Electromagnetic interference (EMI) from the defibrillator impacting other devices especially during charge and energy transfers;
- Incorrectly shocking a pulse sustaining rhythm and inducing VF or cardiac arrest;
- Bystander shock from patient contact during defibrillation shock;
- Interaction with pacemakers;
- Skin burns around the electrode placement area;
- Allergic dermatitis due to sensitivity to materials used in electrode construction; and
- Minor skin rash.

IX. SUMMARY OF PRECLINICAL STUDIES

Pre-clinical information demonstrating the safety and effectiveness of the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20 and LIFEPAK 15 was reviewed by FDA under this PMA. This pre-clinical information included:

- ***Bench Testing:***

  Tables 2 through 4 summarize the major bench testing conducted to demonstrate performance of the LIFEPAK 1000, LIFEPAK 20e and the LIFEPAK 15 devices, including conformance with applicable consensus performance standards.

Table 2: LIFEPAK 1000 Major Bench Testing

Test Title	**Result**
Electrical Safety (IEC 60601-1:2005 Edition 3 and IEC 60601- 2-4:2010 Edition 3)	Pass
Electromagnetic Compatibility (IEC 60601-1-2:2007 Edition 3) with Home Use environment requirements	Pass
Software Verification/Validation	Pass
Environmental Testing	Pass
Shock Advisory System Performance Testing	Pass
Motion Detection Testing	Pass
System Design Verification	Pass
Hardware Design Verification	Pass
Functional Testing	Pass
Battery/Charge Testing	Pass
Energy Accuracy and Waveform Testing	Pass
Time to Shock Ready Testing	Pass
Mechanical (Vibration, Drop, etc.) Testing	Pass
Cleaning Tests	Pass
Packaging Tests	Pass

Table 3: LIFEPAK 20e Major Bench Testing

Test Title	Result
Electrical Safety (IEC 60601-1:2005 Edition 3.1 and IEC 60601- 2-4:2010 Edition 3	Pass
Electromagnetic Compatibility (IEC 60601-1-2:2007 Edition 3) with Home Use environment requirements	Pass
IEC 60601-2-27, Medical electrical equipment, Part 2: Particular Requirements for the Safety, Including Essential Performance of Electrocardiographic Monitoring Equipment	Pass
ISO 80601-2-55, Medical electrical equipment, Part 2: Particular requirements for the basic safety and essential performance of respiratory gas monitors	Pass
ISO 80601-2-61, Medical electrical equipment – Part 2-61: Particular requirements for basic safety and essential performance of pulse oximeter equipment	Pass
IEC 60601-2-49, Medical electrical equipment, Part 2-49: Particular requirements for the basic safety and essential performance of multifunction patient monitoring equipment	Pass
IEC 60601-1-6, Medical electrical equipment, Part 1-6 General requirements for safety - Collateral Standard: Usability	Pass
IEC 60601-1-8, Medical electrical equipment General requirements for basic safety and essential performance – Collateral standard: General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems	Pass
IEC 62304, Medical device software, Software life-cycle processes	Pass
Software Verification/Validation	Pass
Environmental Testing	Pass
Shock Advisory System Performance Testing	Pass
Motion Detection Testing	Pass
System Design Verification	Pass
Hardware Design Verification	Pass
Functional Testing	Pass
Battery/Charge Testing	Pass
Energy Accuracy and Waveform Testing	Pass
Time to Shock Ready Testing	Pass
Mechanical (Vibration, Drop, etc.) Testing	Pass
Cleaning Tests	Pass
Packaging Tests	Pass

Table 4: LIFEPAK 15 Major Bench Testing

Test Title	Result
Electrical Safety (IEC 60601-1:2005 Edition 3 and IEC 60601- 2-4:2010 Edition 3	Pass
IEC 60601-2-25: Medical electrical equipment, Part 2: Particular requirements for the basic safety and essential performance of electrocardiographs	Pass
IEC 60601-2-27: Medical electrical equipment, Part 2: Particular requirements for the basic safety and essential performance of electrocardiographic monitoring equipment.	Pass
IEC 80601-2-30, Medical electrical equipment, Part 2: Particular requirements for	Pass

the basic safety and essential performance of automated non-invasive sphygmomanometers	
IEC 60601-2-34, Medical electrical equipment, Part 2-34: Particular requirements for the basic safety and essential performance of invasive blood pressure monitoring equipment	Pass
IEC 60601-2-49, Medical electrical equipment, Part 2-49: Particular requirements for the basic safety and essential performance of multifunction patient monitoring equipment	Pass
ISO 80601-2-55, Medical electrical equipment, Part 2: Particular requirements for the basic safety and essential performance of respiratory gas monitors	Pass
Electromagnetic Compatibility (IEC 60601-1-2:2007 Edition 3) with Home Use environment requirements	Pass
ISO 80601-2-56, Medical electrical equipment – Part 2-56: Particular requirements for basic safety and essential performance of clinical thermometers for body temperature measurements	Pass
ISO 80601-2-61, Medical electrical equipment – Part 2-61: Particular requirements for basic safety and essential performance of pulse oximeter equipment	Pass
IEC 60601-2, Medical electrical equipment Part 1-6, General requirements for safety	Pass
IEC 60601-1-8, Medical electrical equipment, General requirements for basic safety and essential performance – Collateral standard: General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems	Pass
IEC 60601-1-12, Medical electrical equipment – Part 1-12: General requirements for basic safety and essential performance – Collateral Standard: Requirements for medical electrical equipment and medical electrical systems intended for use in the emergency medical services environment	Pass
IEC 62304, Medical device software, Software life-cycle processes	Pass
Software Verification/Validation	Pass
Environmental Testing	Pass
Shock Advisory System Performance Testing	Pass
Motion Detection Testing	Pass
System Design Verification	Pass
Hardware Design Verification	Pass
Functional Testing	Pass
Battery/Charge Testing	Pass
Energy Accuracy and Waveform Testing	Pass
Time to Shock Ready Testing	Pass
Mechanical (Vibration, Drop, etc.) Testing	Pass
Cleaning Tests	Pass
Packaging Tests	Pass

- ***Software:***

  The software for the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 models were verified/validated and documented as a Major Level of Concern device

according to the FDA guidance document "Guidance for the Content of Premarket Submissions for Software Contained in Medical Devices." The documentation included level of concern, software description, device hazard analysis, software requirements specification, software architecture diagrams, software design specifications, requirements traceability matrix, software development environment description, verification and validation documentation, revision level history, report of unresolved anomalies, discussion of tools to detect runtime errors, and cybersecurity documentation, as applicable. Unit, integration, and system-level testing were documented and demonstrated that the software for the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and the LIFEPAK 15 devices perform as intended.

- ***Defibrillation Waveform:***

  The LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 devices deliver a Biphasic Truncated Exponential waveform into adult-sized electrode pads, with voltage and duration compensation for patient impedance.

  - ***Shock Advisory System (SAS) algorithm:***

    The results of performance testing of the SAS algorithm for the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 models are shown in Tables 5 through 7 below in the context of requirements from IEC 60601-2-4 and the recommendations from the American Heart Association (AHA).

Table 5: LIFEPAK 1000 SAS Performance for Adult Patients:

Rhythm Category	Sample Size	Goal		Test Results	
Shockable			**Correct**	**Sensitivity**	**One-Sided 90% LCL**
Coarse VF	206	>90%	203	98.5%	96.8%
Rapid VT, pulseless	65	>75%	50	76.9%	68.9%
Nonshockable			**Correct**	**Specificity**	**90% LCL**
NSR	509	>99%	509	100.0%	99.5%
Other QRS	749	>95%	743	99.2%	98.6%
Asystole	124	>95%	124	100.0%	98.2%
Intermediate			**Shocked**	**Shocked**	**90% LCL**
Fine VF	32	Report only	17	53.1%	40.4%
Other VT	27	Report only	7	25.9%	15.1%

Table 6: LIFEPAK 1000 SAS Performance for Pediatric Patients:

Rhythm Category	Sample Size	Goal		Test Results	
Shockable			**Correct**	**Sensitivity**	**One-Sided 90% LCL**
Coarse VF	63	>90%	63	100.0%	96.4%
Nonshockable			**Correct**	**Specificity**	**90% LCL**
NSR	69	>99%	69	100.0%	96.7%
Other QRS	507	>95%	507	100.0%	99.5%
Asystole	60	>95%	60	100.0%	96.2%
Intermediate			**Shocked**	**Shocked**	**90% LCL**
Fine VF	1	Report only	1	100.0%	10.0%

Table 7: LIFEPAK 20/20e SAS Performance for Adult Patients:

Rhythm Category	Sample Size	Goal		Test Results	
Shockable			**Correct**	**Sensitivity**	**One-Sided 90% LCL**
Coarse VF	206	>90%	201	97.6%	95.5%
Rapid VT, pulseless	65	>75%	56	86.2%	79.0%
Nonshockable			**Correct**	**Specificity**	**90% LCL**
NSR	509	>99%	509	100.0%	99.5%
Other QRS	749	>95%	739	98.7%	98.0%
Asystole	124	>95%	124	100.0%	98.2%
Intermediate			**Shocked**	**Shocked**	**90% LCL**
Fine VF	32	Report only	11	34.4%	23.1%
Other VT	27	Report only	9	33.3%	21.2%

Table 8: LIFEPAK 20/20e SAS Performance for Pediatric Patients:

Rhythm Category	Sample Size	Goal		Test Results	
Shockable			**Correct**	**Sensitivity**	**One-Sided 90% LCL**
Coarse VF	63	>90%	62	98.4%	94.0%
Nonshockable			**Correct**	**Specificity**	**90% LCL**
NSR	69	>99%	69	100.0%	96.7%
Other QRS	507	>95%	507	100.0%	99.5%
Asystole	60	>95%	60	100.0%	96.2%
Intermediate			**Shocked**	**Shocked**	**90% LCL**
Fine VF	1	Report only	1	100.0%	10.0%

Table 9: LIFEPAK 15 SAS Performance for Adult Patients:

Rhythm Category	Sample Size	Goal		Test Results	
Shockable			**Correct**	**Sensitivity**	**One-Sided 90% LCL**
Coarse VF	206	>90%	202	98.1%	96.2%
Rapid VT, pulseless	65	>75%	55	84.6%	77.3%
Nonshockable			**Correct**	**Specificity**	**90% LCL**
NSR	509	>99%	509	100.0%	99.5%
Other QRS	749	>95%	741	98.9%	98.3%
Asystole	124	>95%	124	100.0%	98.2%
Intermediate			**Shocked**	**Shocked**	**90% LCL**
Fine VF	32	Report only	13	40.6%	28.7%
Other VT	27	Report only	13	48.1%	34.5%

Table 10: LIFEPAK 15 SAS Performance for Pediatric Patients

Rhythm Category	Sample Size	Goal		Test Results	
Shockable			**Correct**	**Sensitivity**	**One-Sided 90% LCL**
Coarse VF	63	>90%	62	98.4%	94.0%
Nonshockable			**Correct**	**Specificity**	**90% LCL**
NSR	69	>99%	69	100.0%	96.7%
Other QRS	507	>95%	507	100.0%	99.5%
Asystole	60	>95%	60	100.0%	96.2%
Intermediate			**Shocked**	**Shocked**	**90% LCL**
Fine VF	1	Report only	1	100.0%	10.0%

[4]Exact single-sided 90% lower confidence limit, calculated using Minitab 16, Basic Statistics for 1 Proportion

- ***Animal Study:***

  LIFEPAK 1000 device:
  To support a pediatric indication for use for the ADAPTIV™ biphasic Waveform, Physio-Control submitted an animal study to the FDA as part of a 510(k) submission (K022732). The results of the animal study were submitted in the test report titled "Pediatric Defibrillation Dosing Summary: Summary of Results" as well as a published article by Berg, et. al., ("Attenuated adult biphasic shocks compared with weight-based monophasic shocks in a swine model of prolonged pediatric ventricular fibrillation")[1].

  The safety and effectiveness of monophasic 2-4 J/kg and attenuated biphasic shocks (ADAPTIV Biphasic waveform) were studied in the resuscitation of 48 immature

swine from 7 minutes of untreated ventricular fibrillation. The weights of the animals studied were representative of the weights of newborn, 3-year-old, and 8-year-old children.

In this animal model of pediatric cardiac arrest, the attenuated biphasic shocks were superior to the monophasic 2-4 J/kg shocks in two (2) ways: (1) they provided a significantly higher survival rate and (2) they were associated with significantly better cardiac function 4 hours after the cardiac arrest. Furthermore, fewer biphasic than monophasic shocks were required during the resuscitation of these animals.

LIFEPAK 20e, LIFEPAK 20 and LIFEPAK 15 devices:
The LIFEPAK 15 and LIFEPAK 20e, LIFEPAK 20 devices are used in manual mode, with standard rather than reduced energy electrodes, on pediatric patients less than 8 years old.

X. SUMMARY OF CLINICAL STUDIES

A new, prospective clinical trial was not conducted using the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20 and LIFEPAK 15 devices. However, publications of prior clinical studies conducted by Physio-Control and considered relevant in demonstrating the safety and effectiveness of the LIFEPAK devices are as listed in Table 8. Further study details can be found within the publications noted below; full citations of the publications are provided in section XV of this SSED.

Table 8: Clinical Studies Relevant to LIFEPAK models

Clinical Study #	Clinical Study	Related Publication
Study #1	Comparison of monophasic vs. biphasic waveforms: in-hospital trial	Higgins, et al., 2000[2]
Study #2	Comparison of monophasic vs. biphasic waveforms: out-of-hospital trial	Van Alem, et al., 2003[3]

A. Clinical Study #1 - Monophasic vs. biphasic waveforms: in-hospital trial

This prospective, double-blinded, randomized clinical trial compared the first shock efficacies of Physio-Control ADAPTIV™ 200J biphasic truncated exponential (BTE) waveform, 130J BTE, and 200J monophasic damped sine shocks (MDS) shocks in the electrophysiology lab, delivered from modified LIFEPAK 7 defibrillators (an early defibrillator cleared under 510(k) K810154, but modified to have the same BTE waveform as the LIFEPAK 500).

Note: The identical BTE (ADAPTIV™ biphasic waveform) used in the LIFEPAK 500 is also used in the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 devices.

Methods: Ventricular fibrillation (VF) was induced in 115 patients during evaluation of implantable cardioverter defibrillator function and 39 patients during electrophysiologic evaluation of ventricular arrhythmias. After 19±10 seconds of VF, a randomized transthoracic shock was administered. The 95% upper confidence limit of the difference in efficacy (95UCLD), control minus test, was required to be less than 10%..

Results: First shock VF termination rates were 61/68 (90%) for the 200J monophasic, 39/39 (100%) for the 200J biphasic, and 39/47 (83%) for 130J biphasic shocks. First shock VT termination rates were 26/28 (93%) for the 200J monophasic, 22/23 (96%) for the 200J biphasic, and 20/21 (95%) for 130J biphasic shocks.

Conclusion: The 200J biphasic shocks were superior in first-shock efficacy to both 200J MDS shocks and 130J BTE shocks. There were no significant differences in hemodynamic parameters between the three (3) groups after successful shocks. The 200J biphasic shocks were more effective than monophasic and the 130J BTE shocks and may allow earlier termination of VF in cardiac arrest patients.

B. Clinical Study #2 - Monophasic vs. biphasic waveforms: out-of-hospital trial

In a publication by Van Alem, et al.[3], the authors noted "Evidence suggests that biphasic waveforms are more effective than monophasic waveforms for defibrillation in out-of-hospital cardiac arrest (OHCA), yet their performance has only been compared in un-blinded studies." The authors subsequently conducted and reported on a clinical trial comparing the effectiveness of the LIFEPAK 500 defibrillation waveform (monophasic versus biphasic). Specifically, the success of biphasic truncated exponential (BTE) and monophasic damped sine (MDS) shocks for defibrillation were compared in a prospective, randomized, double blind clinical trial of out-of-hospital (OOH) cardiac arrest patients.

> Note: The identical ECG analysis Shock Advisory System and BTE (ADAPTIV™ biphasic waveform) used in the LIFEPAK 500 is also used in the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 devices.

Methods: First responders were equipped with either a Physio-Control LIFEPAK 500 MDS or BTE (ADAPTIV™ biphasic waveform) automated external defibrillator (AED) in a random fashion. Patients in ventricular fibrillation (VF) received BTE or MDS first shocks of 200J. The ECG was recorded for subsequent analysis continuously. The success of the first shock as a primary endpoint was removal of VF and required a return of an organized rhythm for at least two (2) QRS complexes, with an interval of <5 seconds, within 1 minute after the first shock. The secondary endpoint was termination of VF at 5 seconds.

Results: VF was the initial recorded rhythm in 120 patients in OHCA, 51 patients received BTE and 69 received MDS shocks. The median time from collapse to first shock was nine (9) minutes for the monophasic shock and 11 minutes for the BTE. The success rate of 200 J first shocks was significantly higher for BTE than for

MDS shocks, 35/51 (69%) and 31/69 (45%), p=0.01. Termination of VF at 5 seconds after the first shock was 91% for the monophasic shock and 98% for BTE waveform. Return of spontaneous circulation was 61% for the Physio-Control defibrillation shock.

In a logistic regression model, the odds ratio of success for a BTE shock was 4.01 (95% CI 1.01-10.0), adjusted for baseline cardiopulmonary resuscitation, VF amplitude and time between collapse and first shock. No difference was found with respect to the secondary endpoint, termination of VF at 5 seconds (RR 1.07 95% CI: 0.99-1.11) and with respect to survival to hospital discharge (RR 0.73 95% CI:0.31-1.70).

Conclusion: The authors concluded that BTE-waveform AEDs provide significantly higher rates of successful defibrillation with return of an organized rhythm in OHCA than MDS waveform AEDs. FDA determined these data support the safety and effectiveness of the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15.

C. Pediatric Defibrillation

In this premarket application, the animal study discussed in Section IV was leveraged to support the reasonable assurance of safety and effectiveness of the proposed device in the pediatric sub-population of children 8 years and older or weighing 25 kg (55 lbs.) or more for the LIFEPAK 1000, LIFEPAK 20/20e, and LIFEPAK 15. In addition to the animal study discussed above, Physio-Control included a postmarket surveillance study to support the safety and effectiveness of pediatric defibrillation using the LIFEPAK 1000 device. The Infant/Child Electrode postmarket surveillance study was initiated in February 2003 and ended in February 2006. The goal of the surveillance activity was to characterize device performance, usage patterns, and customer acceptance of the Infant/Child Electrodes and to identify any unforeseen performance characteristics that could potentially impact the safe and effective use of the attenuated energy Infant/Child Electrode.

The incidence of pediatric cardiac arrest is relatively low in comparison to that of the adult population. Accordingly, a low usage rate of Infant/Child Electrodes was anticipated during the surveillance period. The surveillance incorporated two (2) endpoints, 50 uses or three (3) years, whichever was achieved first. During the 3-year surveillance period, Physio-Control received 21 reports: 19 confirmed uses of the Infant/Child Electrodes with AEDs and two (2) attempts to use the Infant/Child Electrodes with incompatible products. A use was defined as the application of Infant/Child Electrodes to a patient during a resuscitation attempt with or without electrical therapy. Most of the uses involved electrode application appropriate to the age/weight labeling, specifically up to 8 years old or up to 25 kg (551bs); two (2) other uses occurred with children at the upper end of the labeled age range who exceeded the electrodes' weight range category. The Physio-Control defibrillation shock terminated VT/VF in all patients treated.

D. Human Factors

Physio-Control conducted usability evaluations and validations throughout the design and development of the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 to assess the user interface and use-related hazard mitigations with intended users in the intended use environments. Physio-Control also conducted post market complaint analyses related to device usability.

Design validation included simulated use scenarios to assess users' ability to complete the identified critical tasks. BLS and ALS trained medical personnel were required to perform tasks associated with the typical use of device functionality such as device setup, utilization of monitoring and therapy features, using alarms and interpretation of safety-related user interface elements. The tasks for each user group were based on the functions and features they would operate based on their training level. Use problems related to critical tasks were recorded and evaluated through the risk management process to ensure acceptable residual risk.

The usability validations and post market complaint analyses have demonstrated safe and effective use of the LIFEPAK 1000, LIFEPAK 20e, LIFEPAK 20, and LIFEPAK 15 by the intended users in the intended use environments.

E. Financial Disclosure

The Financial Disclosure by Clinical Investigators regulation (21 CFR 54) requires applicants who submit a marketing application to include certain information concerning the compensation to, and financial interests and arrangement of, any clinical investigator conducting clinical studies covered by the regulation. The clinical studies included six (6) investigators of which none were full-time or part-time employees of the sponsor and two (2) investigators had disclosable financial interests/arrangements as defined in 21 CFR 54.2(a), (b), (c) and (f) and described below:

- Compensation to the investigator for conducting the study where the value could be influenced by the outcome of the study: 1 investigator
- Significant payment of other sorts: 1 investigator
- Proprietary interest in the product tested held by the investigator: none
- Significant equity interest held by investigator in sponsor of covered study: none

The applicant has adequately disclosed the financial interest/arrangements with clinical investigators. Statistical analyses were conducted by FDA to determine whether the financial interests/arrangements had any impact on the clinical study outcome. The information provided does not raise any questions about the reliability of the data.

XI. PANEL MEETING RECOMMENDATION AND FDA'S POST-PANEL ACTION

In accordance with the provisions of section 515(c)(3) of the act as amended by the Safe Medical Devices Act of 1990, this PMA was not referred to the Circulatory System Devices Panel, an FDA advisory committee, for review and recommendation because the information in the PMA substantially duplicates information previously reviewed by this panel on January 25, 2011, as part of the 515(i) process. The majority of the panel recommended that AEDs be regulated as Class III PMAs to have better oversight of device manufacturing and postmarket performance.

XII. CONCLUSIONS DRAWN FROM PRECLINICAL AND CLINICAL STUDIES

A. Effectiveness Conclusions

The preclinical and clinical information (including substantial worldwide commercial use, publications, and clinical trials) provided supported reasonable effectiveness of the use of the LIFEPAK 1000, LIFEPAK 20/20e, and LIFEPAK 15 for the defibrillators' indications for use.

B. Safety Conclusions

The preclinical and clinical information (including substantial worldwide commercial use, publications, and clinical trials) provided did not identify unacceptable safety concerns associated with use of the LIFEPAK 1000, LIFEPAK 20/20e, and LIFEPAK 15 for the defibrillators' indications for use.

C. Benefit-Risk Determination

The LIFEPAK 1000, LIFEPAK 20/20e, and LIFEPAK 15 were previously FDA-reviewed and cleared under 510(k) notifications for their current indications for use. Both devices have been in commercial distribution within the U.S. (and numerous other countries of the world) for more than a decade.

The probable benefits of the device are based on two (2) randomized multi-center clinical trials found in the published literature, and pediatric postmarket clinical data, which was collected after 510(k) clearance, described above. The benefit of early defibrillation therapy is survival of patients in cardiac arrest. AEDs are life-saving devices used in emergency situations. They have been shown to have a large benefit for patients with underlying diseases that remain undetected until sudden cardiac arrest occurs. The time from collapse to defibrillation is critical in patient survival. For every minute that passes between collapse and defibrillation, survival rates from VF-related sudden cardiac arrest decrease by 7-10%.

The magnitude of this benefit to an individual is either life or death. The published literature and the pediatric postmarket clinical data have no ability to predict which patients will experience a benefit or determine probability of benefit because of the differing pathophysiology of underlying cardiac arrest. The subpopulations have a high degree of heterogeneity of etiologies of cardiac arrest; therefore, variation in public health benefit cannot be determined. Likewise, the duration of effect is dependent on underlying etiology and, though valuable to the patient, is highly dependent on subsequent treatment of the underlying disease. Duration of effect is not related to the device.

Patients are likely to put a high value on this treatment because it has the potential to save their lives. Patients are therefore willing to accept the risks of this treatment to achieve the benefit. If the treatment provides timely successful defibrillation, the patient will survive a life threatening cardiac arrest situation and will be able to seek further treatment.

Patient Perspectives: This submission did not include specific information on patient perspectives for the device.

D. Overall Conclusions

The data in this application support the reasonable assurance of safety and effectiveness of this device when used in accordance with the indications for use.

XIII. CDRH DECISION

CDRH issued an approval order on July 2, 2018. FDA has developed unique conditions of approval to pursue real world information and in response to panel comments from the 515(i) Panel discussed in Section XI above. The final conditions of approval cited in the approval order are described below.

The applicant will provide the following non-clinical information as part of the annual report, which may be followed by a PMA supplement where applicable.

1. The number of devices returned to the applicant for cause from domestic sources, with a breakdown into:

    a. Those returned for normal end-of-life; and

    b. Those returned with any alleged failures or malfunctions, including a summary of root causes and the frequency of occurrence for each identified root cause.

2. The number of replacement defibrillation pads and replacement batteries issued to customers domestically for all causes.

3. A summary of information available to you related to individual domestic uses of your device that may include, but is not limited to:

    a. Defibrillation success and the number of shocks required for success; and
    b. Identification of any error codes or malfunctions during use and their related MDR number.

4. A listing of any safety alerts, technical service bulletins, user communications, or recalls for devices under this PMA.

The applicant's manufacturing facilities have been inspected and found to be in compliance with the device Quality System (QS) regulation (21 CFR 820).

XIV. APPROVAL SPECIFICATIONS

Directions for use: See device labeling.

Hazards to Health from Use of the Device: See Indications, Contraindications, Warnings, and Cautions in the device labeling.

Post-approval Requirements and Restrictions: See approval order.

XV. REFERENCES

1) Berg RA, Chapman FW, Berg MD, Hilwig RW, Banville I, Walker RG, Nova RC, Sherrill D, Kern KB. Attenuated adult biphasic shocks compared with weight-based monophasic shocks in a swine model of prolonged pediatric ventricular fibrillation. Resuscitation 2004 61:189-197.

2) Higgins SL, Herre JM, Epstein AE, Greer, SG, Freidman PL, Gleva ML, Porterfield JG, Chapman FW, Finkel ES, Schmitt PW, Nova RC, Greene HL. A Comparison of Biphasic and Monophasic Shocks for External Defibrillation. *Prehospital Emergency Care* 2000;4(4):305-313.

3) Van Alem AP, Chapman FW, Lank P, Hart AAM, Koster RW. A prospective, randomised and blinded comparison of first shock success of monophasic and biphasic waveforms in out-of-hospital cardiac arrest. *Resuscitation* 2003;58(1):17-24.