MRI TECHNICAL GUIDE

⚠️ IMAGEREADY™ MR

CONDITIONAL

DEFIBRILLATION SYSTEM

REF: D000, D002, D010, D012, D020, D022, D044, D046, D050, D052, D140, D142, D150, D152, D174, D176, D232, D233, D332, D333, D412, D413, D432, D433, D512, D513, D532, D533, G058, G148, G158, G179, G237, G247, G337, G347, G437, G447, G537, G547, 0262, 0263, 0265, 0266, 0272, 0273, 0275, 0276, 0282, 0283, 0285, 0286, 0289, 0292, 0293, 0295, 0296, 0636, 0650, 0651, 0652, 0653, 0654, 0655, 0657, 0658, 0662, 0663, 0665, 0672, 0673, 0675, 0676, 0682, 0683, 0685, 0686, 0692, 0693, 0695, 0696, 4469, 4470, 4471, 4472, 4473, 4474, 4479, 4480, 4603, 4671, 4672, 4674, 4675, 4677, 4678, 6220, 6221, 6402, 6403, 7145, 7148, 7735, 7736, 7740, 7741, 7742
ABOUT THIS MANUAL

This manual is intended for use by physicians and other health care professionals (HCPs) involved in managing patients with an ImageReady MR Conditional Defibrillation System, as well as radiologists and other HCPs involved in performing magnetic resonance imaging (MRI) scans on such patients.

NOTE: For the purposes of this Technical Guide, MRI is used as a general term and encompasses all MR-based clinical imaging activities. In addition, information in this guide applies only to $^1$H MRI (Proton MRI) scanners.

Read this manual in its entirety before scanning patients who are implanted with an ImageReady MR Conditional Defibrillation System.

This manual contains:

- Information about the ImageReady MR Conditional Defibrillation System (Boston Scientific transvenous ICDs and CRT-Ds)
- Information about ImageReady MR Conditional Defibrillation System patients who can and cannot undergo an MRI scan and the Conditions of Use that must be met in order for an MRI scan to be performed
- Instructions for carrying out an MRI scan on ImageReady MR Conditional Defibrillation System patients

How to use this manual:

1. Refer to the patient’s records to locate model numbers for all components of the patient’s implanted system.

2. Refer to "System Configuration for 1.5 T" on page 1-2 to determine if all components of the patient’s implanted system are found within the tables. If any of the components cannot be found within the tables, the system is not an ImageReady MR Conditional Defibrillation System.

NOTE: Multiple Boston Scientific ImageReady MRI Technical Guides are available based on therapy type, for example, a pacing system versus a defibrillation system. If a particular pulse generator model is not represented in this manual, refer to the other Boston Scientific ImageReady MRI Technical Guides. If a particular model is not represented in any Boston Scientific ImageReady MRI Technical Guide, the patient’s implanted system is not an ImageReady MR Conditional system.


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INTRODUCTION TO THE MR CONDITIONAL DEFIBRILLATION SYSTEM

CHAPTER 1

This chapter contains the following topics:

• “System Description” on page 1-2
• “MRI Conditions of Use” on page 1-3
• “MRI Protection Mode” on page 1-5
• “MRI Basic Concepts” on page 1-5
• “MR Conditional Defibrillation System Warnings and Precautions” on page 1-5
• “Potential Adverse Events” on page 1-7
SYSTEM DESCRIPTION

An ImageReady MR Conditional Defibrillation System consists of specific Boston Scientific model components including pulse generators, leads, accessories, the Programmer/Recorder/Monitor (PRM), and the PRM Software Application. Any part of the body may be imaged. Boston Scientific MR Conditional pulse generators and leads, when used together, have mitigated risks associated with MRI scans as compared to conventional pulse generators and leads. The implanted system, as opposed to its constituent parts, is determined to have the status of MR Conditional as described in ASTM F2503:2008. Prior to the patient undergoing an MRI scan, the ImageReady MR Conditional Defibrillation System must be programmed to MRI Protection Mode. MRI Protection Mode modifies the behavior of the pulse generator to accommodate the MRI scanner electromagnetic environment (“MRI Protection Mode General Information” on page 2-3). A Time-out feature can be programmed to allow automatic exit from MRI Protection Mode after a set number of hours chosen by the user. These features have been evaluated to verify their effectiveness. Other MRI-related risks are further reduced by adherence to the conditions for scanning specified in this Technical Guide.

Only specific combinations of pulse generators and leads constitute an ImageReady Defibrillation System that is valid for use with 1.5 T scanners. For the model numbers of MR Conditional Defibrillation System components, see “System Configuration for 1.5 T” on page 1-2.

For additional information, see the Boston Scientific Website at http://www.bostonscientific.com/imageready.

System Configuration for 1.5 T

Table 1–1. Pulse Generators – ImageReady MR Conditional Defibrillation System

<table>
<thead>
<tr>
<th>Component</th>
<th>Model Number(s)</th>
<th>MR Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTOGEN MINI ICD</td>
<td>D044, D046</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>AUTOGEN EL ICD</td>
<td>D174, D176</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>AUTOGEN X4 CRT-D</td>
<td>G179</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>CHARISMA X4 CRT-D</td>
<td>G337, G347</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>CHARISMA EL ICD</td>
<td>D332, D333</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>DYNAGEN MINI ICD</td>
<td>D020, D022</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>DYNAGEN EL ICD</td>
<td>D150, D152</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>DYNAGEN X4 CRT-D</td>
<td>G158</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>INOGEN MINI ICD</td>
<td>D010, D012</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>INOGEN EL ICD</td>
<td>D140, D142</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>INOGEN X4 CRT-D</td>
<td>G148</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>ORIGEN MINI ICD</td>
<td>D000, D002</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>ORIGEN EL ICD</td>
<td>D050, D052</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>ORIGEN X4 CRT-D</td>
<td>G058</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>PERCIVA HF ICD</td>
<td>D512, D513</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>PERCIVA ICD</td>
<td>D412, D413</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>RESONATE HF CRT-D</td>
<td>G537, G547</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>RESONATE HF ICD</td>
<td>D532, D533</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>RESONATE X4 CRT-D</td>
<td>G437, G447</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>RESONATE EL ICD</td>
<td>D432, D433</td>
<td>MR Conditional</td>
</tr>
</tbody>
</table>
Table 1–1. Pulse Generators – ImageReady MR Conditional Defibrillation System (continued)

<table>
<thead>
<tr>
<th>Component</th>
<th>Model Number(s)</th>
<th>MR Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIGILANT X4 CRT-D</td>
<td>G237, G247</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>VIGILANT EL ICD</td>
<td>D232, D233</td>
<td>MR Conditional</td>
</tr>
</tbody>
</table>

Table 1–2. Leads and Accessories – ImageReady MR Conditional Defibrillation System

<table>
<thead>
<tr>
<th>Component</th>
<th>Model Number(s)</th>
<th>MR Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINELINE II Sterox Pacing Leads</td>
<td>4479, 4480</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>FINELINE II Sterox EZ Pacing Leads</td>
<td>4469, 4470, 4471, 4472, 4473, 4474</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>Suture Sleeves for FINELINE II leads</td>
<td>6220, 6221</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>INGEVITY MRI Pacing Leads (Tined Fixation)</td>
<td>7735, 7736</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>INGEVITY MRI Pacing Leads (Extendable/Retractable Fixation)</td>
<td>7740, 7741, 7742</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>Suture Sleeve for INGEVITY MRI leads</td>
<td>6402</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>IS-1 Lead Port Plug</td>
<td>7145</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>ENDOTAK RELIANCE (DF4) Defibrillation Leads</td>
<td>0262, 0263, 0265, 0266, 0272, 0273, 0275, 0276, 0282, 0283, 0285, 0286, 0292, 0293, 0295, 0296</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>RELIANCE 4-FRONT (DF4) Defibrillation Leads</td>
<td>0636, 0650, 0651, 0652, 0653, 0654, 0655, 0657, 0658, 0662, 0663, 0665, 0672, 0673, 0675, 0676, 0682, 0683, 0685, 0686, 0692, 0693, 0695, 0696</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>Suture Sleeve for RELIANCE 4-FRONT leads</td>
<td>6403</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>ACUITY X4 (IS4) Pacing Leads</td>
<td>4671, 4672, 4674, 4675, 4677, 4678</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>Suture Sleeve for ACUITY X4 leads</td>
<td>4603</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>IS4/DF4 Lead Port Plug</td>
<td>7148</td>
<td>MR Conditional</td>
</tr>
</tbody>
</table>

Table 1–3. ZOOM LATITUDE Programmer/Recorder/Monitor (PRM) and PRM Software Application

<table>
<thead>
<tr>
<th>Component</th>
<th>Model Number(s)</th>
<th>MR Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZOOM LATITUDE PRM</td>
<td>3120</td>
<td>MR Unsafe a</td>
</tr>
<tr>
<td>ZOOM LATITUDE PRM Software Application</td>
<td>2868</td>
<td>N/A</td>
</tr>
</tbody>
</table>

a. See PRM is MR Unsafe Warning regarding the PRM.

MRI CONDITIONS OF USE

The following Conditions of Use must be met in order for a patient with an ImageReady Defibrillation System to undergo an MRI scan. Adherence to the Conditions of Use must be verified prior to each scan to ensure that the most up-to-date information has been used to assess the patient's eligibility and readiness for an MR Conditional scan.

Cardiology

1. Patient is implanted with an ImageReady MR Conditional Defibrillation System (see "System Description" on page 1-2).

   Only a Boston Scientific MR Conditional pulse generator and lead(s), with all ports occupied by a lead or port plug, constitute an ImageReady MR Conditional Defibrillation System. Another manufacturer's MR Conditional pulse generator combined with a
Introduction to the MR Conditional Defibrillation System

2. No other active or abandoned implanted devices, components, or accessories present such as lead adaptors, extenders, leads, or pulse generators.

   *Mitigation of risks associated with MRI scans has not been demonstrated when other cardiac implants or accessories such as lead adaptors, extenders, or abandoned leads or pulse generators are present.*

3. Pulse generator is in MRI Protection Mode during scan.

4. As soon as MRI Protection Mode is programmed, the patient must be continuously monitored by pulse oximetry and electrocardiography (ECG). Ensure backup therapy is available (external rescue).

5. Patient is judged to be clinically capable of tolerating no Tachycardia protection for the entire duration in which the pulse generator is in MRI Protection Mode.

6. Patient does not have elevated body temperature or compromised thermoregulation at time of scan.

7. Pulse generator implant location restricted to left or right pectoral region.

8. At least six (6) weeks have elapsed since implantation and/or any lead revision or surgical modification of the MR Conditional Defibrillation System.

   *A six-week period allows for healing and scar tissue formation, which reduce the impact of potential risks associated with MRI scans such as heating or movement.*

9. No evidence of a fractured lead or compromised pulse generator-lead system integrity.

   *Mitigation of risks associated with MRI scans has not been demonstrated if the lead and/or the pulse generator-lead system integrity are compromised.*

Radiology

<table>
<thead>
<tr>
<th>1. MRI magnet strength</th>
<th>1.5 T only</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF field</td>
<td>Approximately 64 MHz</td>
</tr>
<tr>
<td>Maximum spatial gradient</td>
<td>50 T/m (5,000 G/cm)</td>
</tr>
<tr>
<td>MRI equipment specification</td>
<td>Horizontal, $^1$H proton, closed bore scanners only</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Specific Absorption Rate (SAR) limits for the entire active scan</th>
<th>Normal Operating Mode$^a$ :</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Whole body averaged, ≤ 2.0 watts/kilogram (W/kg)</td>
</tr>
<tr>
<td></td>
<td>• Head, ≤ 3.2 W/kg</td>
</tr>
</tbody>
</table>

| 3. Maximum specified gradient slew rate | ≤ 200 T/m/s per axis |

4. There are no restrictions for positioning the defibrillation system within the integrated body coil of the MRI scanner. The use of receive-only coils is not restricted. Local transmit-only coils or local transmit/receive coils may be used, but should not be placed directly over the defibrillation system.

5. Patient in supine or prone position only.

6. Patient must be continuously monitored by pulse oximetry and electrocardiography (ECG) for the entire duration in which the pulse generator is in MRI Protection Mode. Ensure backup therapy is available (external rescue).

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$^a$. As defined in IEC 60601-2-33, 201.3.224, 3rd Edition.

The system response to conditions other than those listed for the radiology conditions described in the preceding table has not been evaluated.
MRI PROTECTION MODE

In preparation for an MRI scan, the pulse generator must be programmed into MRI Protection Mode using the programmer. MRI Protection Mode modifies certain pulse generator functions in order to mitigate risks associated with exposing the ImageReady MR Conditional System to the MRI environment. For a list of features and functions that are suspended in MRI Protection Mode, see “MRI Protection Mode General Information” on page 2-3.

MRI BASIC CONCEPTS

MRI is a diagnostic tool that uses three types of magnetic and electromagnetic fields to image soft tissue in the body:

- A static magnetic field generated by a superconducting electromagnet coil, 1.5 T in strength.
- Gradient magnetic fields of much lower intensity, but with high rates of change over time. Three sets of gradient coils are used to create the gradient fields.
- A pulsed radio frequency (RF) field produced by transmission RF coils (approximately 64 MHz for 1.5 T).

These fields may create physical forces or electrical currents that can affect the functioning of active implantable medical devices (AIMDs) such as pulse generators and leads. Therefore, only patients implanted with an MR Conditional system are eligible to be scanned. Furthermore, by complying with the MRI Conditions of Use, outlined in this Technical Guide ("MRI Conditions of Use" on page 1-3), ImageReady MR Conditional System patients can undergo MRI scans with risks mitigated to the best current standard of care.

MR CONDITIONAL DEFIBRILLATION SYSTEM WARNINGS AND PRECAUTIONS

General

WARNING: Unless all of the MRI Conditions of Use ("MRI Conditions of Use" on page 1-3) are met, MRI scanning of the patient does not meet MR Conditional requirements for the implanted system, and significant harm to or death of the patient and/or damage to the implanted system may result.

For potential adverse events applicable when the Conditions of Use are met or not met, see "Potential Adverse Events" on page 1-7.

WARNING: MRI scanning after Explant status has been reached may lead to premature battery depletion, a shortened device replacement window, or sudden loss of therapy. After performing an MRI scan on a device that has reached Explant status, verify pulse generator function and schedule device replacement.

WARNING: When the Time-out parameter is programmed to a value other than Off, the patient must be out of the scanner before the time programmed elapses. Otherwise, the patient will no longer meet Conditions of Use ("MRI Conditions of Use" on page 1-3).

WARNING: The Beeper will no longer be usable following an MRI scan. Coming in contact with the strong magnetic field of an MRI scanner causes a permanent loss of the Beeper volume. This cannot be recovered, even after leaving the MR scan environment and exiting MRI Protection Mode. Before an MRI procedure is performed, a physician and patient should weigh the benefit of the MR procedure against the risk of losing the Beeper. It is strongly recommended that patients are followed on LATITUDE NXT after an MRI scan if they are not already. Otherwise, an in-clinic follow-up schedule of every three months is strongly recommended to monitor device performance.
WARNING: During MRI Protection Mode, the patient will not receive Tachycardia therapy (including ATP and defibrillation), and, if Brady Mode is programmed to Off, will not receive Bradycardia pacing (including backup pacing) and Cardiac Resynchronization Therapy. Therefore the patient must be continuously monitored for the entire duration in which the system is in MRI Protection Mode, including during the scan.

Programming Considerations

WARNING: If the MRI Protection Time-out value is programmed to Off, the patient will not receive Tachycardia therapy, and the pacing options are limited to Off or Asynchronous until the pulse generator is programmed out of MRI Protection Mode and back to normal operation.

WARNING: Use caution when programming MRI Protection Mode in pacing-dependent patients who have high right atrial and right ventricular pacing thresholds on the paced lead(s) (> 2.0 V). The maximum pacing amplitude in MRI Protection Mode is 5.0 V, which may limit the available pacing amplitude safety margin for patients with high pacing thresholds. Failure to maintain sufficient pacing amplitude safety margin may result in loss of capture.

WARNING: During MRI Protection Mode, Tachycardia therapy is suspended. The system will not detect ventricular arrhythmias and the patient will not receive ATP or shock defibrillation therapy until the pulse generator is programmed back to normal operation. Only scan the patient if judged to be clinically capable of tolerating no Tachycardia protection for the entire duration in which the pulse generator is in MRI Protection Mode.

WARNING: During MRI Protection Mode, if Brady Mode is programmed to Off, Bradycardia therapy and Cardiac Resynchronization Therapy (CRT) are suspended. The patient will not receive pacing until the pulse generator is programmed back to normal operation. Only program Brady Mode to Off during MRI Protection Mode and scan the patient if judged to be clinically capable of tolerating no Bradycardia therapy (including pacing-dependence or need for overdrive pacing) and no CRT for the entire duration in which the pulse generator is in MRI Protection Mode. It is recommended to have a programmer powered On near the MRI room in case the patient develops the urgent need for pacing. Patients with the following conditions may have increased risk of developing transient pacing-dependence:

- At risk for intermittent AV block (for example, those with progressive AV block, or a history of unexplained syncope)
- At risk for trifascicular block (alternating bundle branch block or PR interval > 200 ms with LBBB or other bifascicular block)

WARNING: The risk of arrhythmia may be increased with asynchronous pacing (AOO, VOO, DOO). When programming asynchronous pacing during MRI Protection Mode, select a pacing rate that avoids competitive pacing and minimize the time in MRI Protection Mode.

WARNING: If Bradycardia, CRT, and/or Tachycardia therapy are programmed Off prior to entering MRI Protection Mode, the therapy will remain Off when the MRI Protection Time-out elapses after the programmed time period.

Safety Mode

WARNING: Do not perform an MRI scan on a patient whose device has entered Safety Mode. Safety Mode pacing is VVI unipolar, which, in the MRI environment, subjects the patient to increased risk of arrhythmia induction, inappropriate pacing, inhibition of pacing, or irregular intermittent capture or pacing.

WARNING: In the rare event that non-recoverable or repeat fault conditions occur while the device is programmed in MRI Protection Mode, the subsequent device behavior will be determined by the MRI Protection Brady Mode setting.
• If MRI Brady Mode is set to Off, the device will enter Safety Mode (permanent VVI unipolar pacing and tachycardia therapy enabled).

• If MRI Brady Mode is set to asynchronous pacing (AOO, VOO, DOO), both bradycardia therapy and tachycardia therapy will be permanently disabled.

MRI Site Zone III Exclusions

**WARNING:** The Programmer/Recorder/Monitor (PRM) is MR Unsafe and must remain outside the MRI site Zone III (and higher) as defined by the American College of Radiology Guidance Document for Safe MR Practices. Under no circumstances should the PRM be brought into the MRI scanner room, the control room, or the MRI site Zone III or IV areas.

**WARNING:** Implant of the system cannot be performed in an MRI site Zone III (and higher) as defined by the American College of Radiology Guidance Document for Safe MR Practices. Some of the accessories packaged with pulse generators and leads, including the torque wrench and stylet wires, are not MR Conditional and should not be brought into the MRI scanner room, the control room, or the MRI site Zone III or IV areas.

Precautions

**CAUTION:** The physician choosing MRI Protection Mode parameter values will need to exercise professional judgment to determine an individual patient’s ability to tolerate the device settings required for MR Conditional scanning, in conjunction with the physical conditions required during a scan (for example, prolonged time in a supine position).

**CAUTION:** The presence of the implanted defibrillation system may cause MRI image artifacts (see "Preparing the Patient for the Scan" on page 2-11).

**NOTE:** All normal risks associated with an MRI procedure apply to MRI scans with the MR Conditional Defibrillation System. Consult MRI scanner documentation for a complete list of risks associated with MRI scanning.

**NOTE:** Other implanted devices or patient conditions may cause a patient to be ineligible for an MRI scan, independent of the status of the patient’s ImageReady MR Conditional Defibrillation System.

POTENTIAL ADVERSE EVENTS

Potential adverse events differ depending on whether the MRI Conditions of Use (“MRI Conditions of Use” on page 1-3) are met. For a complete list of potential adverse events, refer to the Physician’s Technical Manual for the pulse generator.

MRI scanning of patients when the Conditions of Use are met could result in the following potential adverse events:

• Arrhythmia induction

• Bradycardia

• Patient death

• Patient discomfort due to slight movement or heating of the device

Introduction to the MR Conditional Defibrillation System

Potential Adverse Events

- Side effects of pacing at a fixed high rate such as competition with intrinsic rhythms and arrhythmias. Competitive pacing may increase the rate of pacing induced arrhythmia until the device is reprogrammed.

- Syncope

- Worsening heart failure

MRI scanning of patients when the Conditions of Use are NOT met could result in the following potential adverse events:

- Arrhythmia induction

- Bradycardia

- Damage to the pulse generator and/or leads

- Erratic pulse generator behavior

- Inappropriate pacing, inhibition of pacing, failure to pace

- Increased rate of lead dislodgement (within six weeks of implant or revision of system)

- Irregular or intermittent capture or pacing

- Loss of defibrillation therapy

- Pacing threshold changes

- Patient death

- Patient discomfort due to movement or heating of the device

- Physical movement of pulse generator and/or leads

- Sensing changes

- Syncope

- Worsening heart failure
MRI SCAN PROCEDURE PROTOCOL

CHAPTER 2

This chapter contains the following topics:

• “Patient Flow” on page 2-2
• “MRI Protection Mode General Information” on page 2-3
• “Pre-Scan Activities” on page 2-4
• “After the Scan” on page 2-12
Before proceeding with this MRI scan procedure protocol, verify that the patient and the MRI scanner meet the MRI Conditions of Use ("MRI Conditions of Use" on page 1-3). This verification must be performed prior to each scan to ensure that the most up-to-date information has been used to assess the patient’s eligibility and readiness for an MR Conditional scan.

**WARNING:** Unless all of the MRI Conditions of Use ("MRI Conditions of Use" on page 1-3) are met, MRI scanning of the patient does not meet MR Conditional requirements for the implanted system, and significant harm to or death of the patient and/or damage to the implanted system may result.

For potential adverse events applicable when the Conditions of Use are met or not met, see "Potential Adverse Events" on page 1-7.

**PATIENT FLOW**

A sample patient flow sequence for an ImageReady Defibrillation System patient who needs an MRI scan is described below. For a more detailed description of the programming and scanning procedure, see this chapter:

1. MRI recommended to patient by specialist (for example, orthopedist or oncologist).

2. Patient or specialist or radiologist contacts the electrophysiologist/cardiologist who manages the patient’s MR Conditional Defibrillation System.

3. Electrophysiologist/cardiologist determines patient eligibility for scan per the information in this Technical Guide, and ensures communication of patient eligibility to HCPs involved in performing the MRI scan. Before an MRI procedure is performed, a physician and patient should weigh the benefit of the MR procedure against the risk of losing the Beeper (Figure 2–9 Beep disabled Summary dialog on page 2-11).

4. If the patient is eligible, the PRM is used to put the pulse generator into MRI Protection Mode as close in time to the scan as reasonable. Ensure continuous monitoring of the patient while in MRI Protection Mode. The MRI Protection Settings Report is printed, placed in the patient’s file, and provided to radiology personnel. The report documents MRI Protection Mode settings and details. If the Time-out feature is used, the report includes the exact time and date when MRI Protection Mode will expire.

5. The radiologist checks the patient file and any communication from the electrophysiologist/cardiologist. If the Time-out feature is used, the radiologist verifies that adequate time remains to complete the scan. Ensure continuous monitoring of the patient before, during, and after the MRI scan.

   **NOTE:** The patient must be continuously monitored for the entire duration in which the system is in MRI Protection Mode. Continuous monitoring includes maintaining normal voice and visual contact, as well as monitoring pulse oximetry and ECG for the entire duration that the pulse generator is in MRI Protection Mode. Ensure that an external defibrillator and medical personnel skilled in cardiopulmonary resuscitation (CPR) are present when the patient is put into MRI Protection Mode.

6. Patient undergoes scan according to the conditions of use described in this Technical Guide.

7. The pulse generator is returned to pre-MRI operation, either automatically if the Time-out parameter was set, or manually using the PRM. Perform follow-up testing of the implanted system. It is strongly recommended that patients are followed on LATITUDE NXT after an MRI scan if they are not already. Otherwise, an in-clinic follow-up schedule of every three months is strongly recommended to monitor device performance.
MRI PROTECTION MODE GENERAL INFORMATION

Prior to the patient undergoing an MRI scan, an ImageReady MR Conditional Defibrillation System must be programmed to the MRI Protection Mode using the PRM. See "Programming the Pulse Generator for a Scan" on page 2-4 for details about programming the pulse generator into MRI Protection Mode.

Tachycardia therapy is suspended in MRI Protection Mode.

Pacing mode options include asynchronous pacing (DOO, AOO, VOO) or no pacing (Off). Asynchronous pacing should only be used if the patient is pacing-dependent. If MRI Protection Brady Mode is programmed to Off, the patient will not receive therapy until MRI Protection Mode is exited. Off should only be used if the patient is judged to be clinically capable of receiving no pacing during the time the pulse generator is in MRI Protection Mode, including during the scan.

Considerations prior to choosing asynchronous pacing include:

- Determine whether the patient is pacing-dependent.
- Determine which chamber(s) need to be paced.
- Consider the possibility of arrhythmia induction with asynchronous pacing.
- Patients with the following conditions may have increased risk of developing transient pacing-dependence:
  1. At risk for intermittent AV block (for example, those with progressive AV block, or a history of unexplained syncope)
  2. At risk for trifascicular block (alternating bundle branch block or PR interval > 200 ms with LBBB or other bifascicular block)

The Beeper is disabled in MRI Protection Mode and will no longer be usable following an MRI scan (Figure 2–9 Beeper disabled Summary dialog on page 2-11).

The following features and functions are suspended in MRI Protection Mode:

- Bradycardia sensing
- Tachycardia detection and therapy
- PaceSafe automatic threshold(s)
- Daily diagnostics (Lead Impedance, Intrinsic Amplitude, Pace Threshold)
- Motion and respiratory sensors
- Magnet detection
- RF telemetry
- Battery voltage monitoring
- Left Ventricular MultiSite Pacing (RESONATE HF G547, RESONATE X4 G447, CHARISMA X4 G347, VIGILANT X4 G247)

The following device conditions will preclude the user from having the option to enter MRI Protection Mode (see the Reference Guide for the pulse generator for additional information about these conditions):
Pre-Scan Activities

- Battery capacity status is Depleted
- Pulse generator is in Storage Mode
- Pulse generator is in Electrocautery Mode
- Pulse generator is in Safety Core operation (Safety Mode)
- Diagnostic test is in progress
- EP test is in progress

**NOTE:** Six hours in MRI Protection Mode reduces pulse generator longevity by approximately 3 days (CRT-D) or 4 days (ICD).

**WARNING:** MRI scanning after Explant status has been reached may lead to premature battery depletion, a shortened device replacement window, or sudden loss of therapy. After performing an MRI scan on a device that has reached Explant status, verify pulse generator function and schedule device replacement.

**PRE-SCAN ACTIVITIES**

Three activities are required before the MRI scan takes place:

1. Prepare the pulse generator for the scan by programming into MRI Protection Mode (“Programming the Pulse Generator for a Scan” on page 2-4)

2. Confirm the MRI scanner settings and configurations (“Confirming MRI Scanner Settings and Configuration” on page 2-11)

3. Prepare the patient for the scan (“Preparing the Patient for the Scan” on page 2-11)

**Programming the Pulse Generator for a Scan**

Use the PRM to program the pulse generator into MRI Protection Mode.

**NOTE:** See "MR Conditional Defibrillation System Warnings and Precautions" on page 1-5 for a complete list of Warnings and Precautions.

**NOTE:** Maintain access to the programmer wand as wanded telemetry is required to enter MRI Protection Mode.

**CAUTION:** The physician choosing MRI Protection Mode parameter values will need to exercise professional judgment to determine an individual patient’s ability to tolerate the device settings required for MR Conditional scanning, in conjunction with the physical conditions required during a scan (for example, prolonged time in a supine position).

Prior to starting programming, print the Device Settings Report as a reference for choosing Brady settings in MRI Protection Mode.

From the Main screen, use the Tachy Mode button to enable MRI Protection Mode. The Change Device Mode screen is displayed (Figure 2–1 Change Device Mode dialog on page 2-5).
Select the Enable MRI Protection button and then choose Continue to proceed with entry into MRI Protection Mode.

The MRI Protection Checklist screen is displayed (Figure 2–2 MRI Protection Checklist on page 2-5). The Checklist summarizes the conditions that must be met at the time of scanning in order for a patient to be eligible for an MR Conditional scan. Re-verification is required before every scan to guard against the possibility that changes in the system or patient occurred subsequent to the original pulse generator/system implant.

If the Conditions of Use as described in this manual are met, select the Continue with MRI Protection button. As a result, the Program MRI Protection screen appears (Figure 2–3 Program MRI Protection dialog on page 2-6).

If the Conditions of Use are not met, select the Cancel button to return to normal system operation and do not proceed with the MRI scan (the patient shall not undergo an MRI scan).
Select a Brady Mode (Figure 2–3 Program MRI Protection dialog on page 2-6). Pacing mode options include asynchronous pacing (DOO, AOO, VOO) or no pacing (Off). Asynchronous pacing should only be used if the patient is pacing-dependent.

**WARNING:** During MRI Protection Mode, if Brady Mode is programmed to Off, Bradycardia therapy and Cardiac Resynchronization Therapy (CRT) are suspended. The patient will not receive pacing until the pulse generator is programmed back to normal operation. Only program Brady Mode to Off during MRI Protection Mode and scan the patient if judged to be clinically capable of tolerating no Bradycardia therapy (including pacing-dependence or need for overdrive pacing) and no CRT for the entire duration in which the pulse generator is in MRI Protection Mode. It is recommended to have a programmer powered On near the MRI room in case the patient develops the urgent need for pacing. Patients with the following conditions may have increased risk of developing transient pacing-dependence:

- At risk for intermittent AV block (for example, those with progressive AV block, or a history of unexplained syncope)
- At risk for trifascicular block (alternating bundle branch block or PR interval > 200 ms with LBBB or other bifascicular block)

If asynchronous pacing is required, program the following additional pacing parameters (Figure 2–4 Program MRI Protection dialog with parameters on page 2-7).

- Lower rate limit defaults to 20 min⁻¹ above normal mode LRL (programmable in normal increments to a maximum value 100 min⁻¹)
  
  **NOTE:** Because MRI Protection Mode pacing is asynchronous, when setting the lower rate limit, consider the patient’s intrinsic rate to avoid competitive pacing.

- Atrial and right ventricular amplitude default to 5.0 V (programmable in normal increments from 2.0 V to 5.0 V) and pulse width fixed at 1.0 ms
  
  **NOTE:** Programming pacing amplitude below 5.0 V is provided as an option in case of extracardiac stimulation (for example, diaphragmatic stimulation).

**WARNING:** Use caution when programming MRI Protection Mode in pacing-dependent patients who have high right atrial and right ventricular pacing thresholds on the paced lead(s) (> 2.0 V). The maximum pacing amplitude in MRI Protection Mode is 5.0 V, which may limit the available pacing amplitude safety margin for patients with high pacing thresholds. Failure to maintain sufficient pacing amplitude safety margin may result in loss of capture.

- Left ventricular amplitude defaults to the normal Brady value when within the range of 2.0 V to 5.0 V (inclusive) (programmable in normal increments from 2.0 V to 5.0 V) and pulse width...
defaults to the normal Brady setting (programmable in normal increments from 0.1 ms to 2.0 ms)

**NOTE:** If the normal Brady value is outside of the 2.0 V to 5.0 V range, the MRI amplitude value will be set to the nearest end of the value range. For example, if the normal Brady value is 1.0 V, the MRI value will be set to 2.0 V.

**NOTE:** In MRI Protection Mode, the minimum allowed pacing amplitude is 2.0 V. Patients whose devices are nominally programmed with LV pacing amplitude less than 2.0 V may experience extracardiac stimulation or phrenic nerve stimulation (PNS) in MRI Protection Mode as the result of the increased LV pacing amplitude. If the patient does not require LV pacing, consider programming the MRI Protection Ventricular Pacing Chamber to RV Only and minimize the time in MRI Protection Mode.

Set MRI Protection Time-out (nominally set to 6 hours; programmable values of Off, 3, 6, 9, 12 hours). The MRI Protection Mode Time-out function allows the user to choose the length of time the pulse generator remains in MRI Protection Mode. Check that the programmer clock is set to the correct time and date to ensure the accuracy of the projected expiration time (displayed on the screen and on the printed MRI Protection Settings Report). When the programmed time has elapsed, the pulse generator automatically exits MRI Protection Mode and all parameters (except for the Beeper) return to the previously programmed settings.

**WARNING:** When the Time-out parameter is programmed to a value other than Off, the patient must be out of the scanner before the time programmed elapses. Otherwise, the patient will no longer meet Conditions of Use ("MRI Conditions of Use" on page 1-3).

**WARNING:** If the MRI Protection Time-out value is programmed to Off, the patient will not receive Tachycardia therapy, and the pacing options are limited to Off or Asynchronous until the pulse generator is programmed out of MRI Protection Mode and back to normal operation.

Select the Program MRI Protection button. The MRI Protection Programmed screen appears when the device has successfully been programmed into MRI Protection Mode at the settings indicated (Figure 2–5 MRI Protection Programmed dialog on page 2-8). Do not proceed with the scan until the MRI Protection Programmed screen is seen to confirm that the device is in MRI Protection Mode.

**NOTE:** Use of the wand is necessary to complete entry into MRI Protection Mode. Keep the wand in place until receiving confirmation that MRI Protection Mode is programmed.
Programming the Pulse Generator for a Scan

WARNING: During MRI Protection Mode, the patient will not receive Tachycardia therapy (including ATP and defibrillation), and, if Brady Mode is programmed to Off, will not receive Bradycardia pacing (including backup pacing) and Cardiac Resynchronization Therapy. Therefore the patient must be continuously monitored for the entire duration in which the system is in MRI Protection Mode, including during the scan.

Continuously monitor the patient for the entire duration in which the system is in MRI Protection Mode. Continuous monitoring includes maintaining normal voice and visual contact, as well as monitoring pulse oximetry and ECG for the entire duration that the pulse generator is in MRI Protection Mode. Ensure that an external defibrillator and medical personnel skilled in cardiopulmonary resuscitation (CPR) are present as long as the pulse generator is in MRI Protection Mode, including during the scan, should the patient require external rescue.

Once MRI Protection Mode has successfully been programmed, print a copy of the MRI Protection Settings Report by selecting the Print Settings button on the MRI Protection Mode Programmed screen. The report lists the settings in operation during MRI Protection Mode. If the Time-out feature is used, the report includes the time and date when MRI Protection Mode will expire, returning the pulse generator to the pre-MRI Protection Mode settings.

The printed report can be placed in the patient's file and used by radiology personnel, for example, to confirm that sufficient time remains to complete the MRI scan. Sample MRI Protection Settings Report printouts are shown with the Time-out set to 6 hours (Figure D–1 Sample MRI Protection Settings Report printout with Time-out set to 6 hours (Pages 1–2) on page D-1) and with the Time-out set to Off (Figure D–2 Sample MRI Protection Settings Report printout with Time-out set to Off (Page 1) on page D-2).

Select the End Session button to end the current programmer session with MRI Protection Mode active in the pulse generator (Figure 2–6 End Session Confirmation dialog on page 2-8).
Ensure that the HCPs involved in performing the MRI scan have received the model numbers of the pulse generator and lead(s) implanted in the patient.

**Conditions Assessed During Programming**

Certain conditions will prevent entry into MRI Protection Mode. These include:

- A ventricular episode as detected and recognized by the pulse generator is in progress
- Magnet presence is detected by magnet sensor
- Pulse generator is in STAT PACE or STAT SHOCK mode

If one or more of these conditions are present, a dialog box will appear describing the condition, and MRI Protection Mode cannot be entered. For example, see Figure 2–7 Episode in progress attention message on page 2-9.

In addition to the conditions listed above that prevent entry into MRI Protection Mode, three other conditions are assessed by the PRM during programming: lead impedance, time since implant, and pacing threshold.

1. **Lead Impedance**

   A user request to enter the MRI Protection Mode triggers a lead impedance test in all chambers and a shock lead impedance test. If the lead impedance values obtained from this testing are outside the programmed normal range, the PRM provides a dialog box recommending a review of the associated risks if the user chooses to proceed. The dialog provides the option of continuing with MRI Protection Mode in the presence of these conditions, or cancelling entry into MRI Protection Mode. The dialog box that appears in the case of an out-of-range lead impedance value is shown in Figure 2–8 Lead impedance out of range attention message on page 2-9.
2. **Time Since implant**

The PRM also determines the time since implant, based on the date and time when the pulse generator was taken out of Storage Mode.

**NOTE:** If the PRM clock is not set to the correct time and date, this determination may not be accurate.

If the calculated time since exit from Storage Mode is less than 6 weeks, the PRM provides a dialog box recommending a review of the associated risks if the user chooses to proceed. The dialog provides the option of continuing with MRI Protection Mode in the presence of these conditions, or cancelling entry into MRI Protection Mode.

3. **Pacing Threshold**

If the most recently recorded RA and RV pacing threshold measurements are greater than 2.0 V, the PRM provides a dialog box recommending the use of caution for pacing-dependent patients. The dialog provides the option of continuing with MRI Protection Mode in the presence of these conditions, or cancelling entry into MRI Protection Mode.

**WARNING:** Use caution when programming MRI Protection Mode in pacing-dependent patients who have high right atrial and right ventricular pacing thresholds on the paced lead(s) (> 2.0 V). The maximum pacing amplitude in MRI Protection Mode is 5.0 V, which may limit the available pacing amplitude safety margin for patients with high pacing thresholds. Failure to maintain sufficient pacing amplitude safety margin may result in loss of capture.

**Beeper**

The Beeper will no longer be usable following an MRI scan. Coming in contact with the strong magnetic field of an MRI scanner causes a permanent loss of the Beeper volume. This cannot be recovered, even after leaving the MR scan environment and exiting MRI Protection Mode. The system proactively disables the programmable and non-programmable Beeper options when MRI Protection Mode is programmed. The Beeper will remain Off upon exiting MRI Protection Mode.

Upon subsequent interrogations, a notification that the Beeper is disabled and the date MRI Protection Mode was last programmed will be provided on the initial Summary dialog (Figure 2–9 Beeper disabled Summary dialog on page 2-11).
The following are situations that will no longer trigger the Beeper to emit audible tones once the device is programmed into MRI Protection Mode.

<table>
<thead>
<tr>
<th>Programmable Beeper options</th>
<th>Non-Programmable Beeper options</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Beep During Capacitor Charge</td>
<td>• Application of the patient magnet over the pulse generator in certain situations (e.g. confirming Tachycardia Mode)</td>
</tr>
<tr>
<td>• Beep When Out-of-Range</td>
<td>• Battery capacity depleted (End of Life (EOL))</td>
</tr>
<tr>
<td>• Beep when Explant is Indicated</td>
<td>• Battery fault alert</td>
</tr>
</tbody>
</table>

The Beeper will emit tones following reversion of the pulse generator to Safety Mode Operation or device reset even after the device is programmed into MRI Protection Mode. But the Beeper volume in the device will be decreased and may be inaudible.

**NOTE:** In situations where the MRI scan did not occur, the Beeper can be re-enabled after exiting MRI Protection Mode ("After the Scan" on page 2-12).

**Confirming MRI Scanner Settings and Configuration**

Ensure that the MRI scanner equipment meets the "MRI Conditions of Use" on page 1-3.

**Preparing the Patient for the Scan**

If the MRI Protection Mode Time-out feature is being used, be sure to note the time at which the pulse generator is scheduled to exit MRI Protection Mode. Refer to Figure 2–5 MRI Protection Programmed dialog on page 2-8.
NOTE: If the time remaining is not sufficient for the patient to undergo the MRI scan, re-interrogate the device and reprogram the Time-out value as desired (see "Programming the Pulse Generator for a Scan" on page 2-4).

WARNING: When the Time-out parameter is programmed to a value other than Off, the patient must be out of the scanner before the time programmed elapses. Otherwise, the patient will no longer meet Conditions of Use ("MRI Conditions of Use" on page 1-3).

Patient position within the bore must be prone or supine, and the appropriate monitoring system must be put in place (pulse oximetry and ECG). See "MRI Conditions of Use" on page 1-3.

WARNING: During MRI Protection Mode, the patient will not receive Tachycardia therapy (including ATP and defibrillation), and, if Brady Mode is programmed to Off, will not receive Bradycardia pacing (including backup pacing) and Cardiac Resynchronization Therapy. Therefore the patient must be continuously monitored for the entire duration in which the system is in MRI Protection Mode, including during the scan.

Image distortion and artifacts must be considered when planning an MRI scan and when interpreting MRI images in proximity to the pulse generator and/or leads. Distortion and artifacts may occur beyond the boundaries of the pulse generator. Only minor artifacts are present around the leads.

AFTER THE SCAN

1. Exit MRI Protection

MRI Protection Mode can be exited either automatically or manually. Exit occurs automatically after the programmed number of hours has elapsed if the Time-out feature is set to a numerical value. If the Timer is programmed to Off, exit is performed manually using the PRM (see Manual Exit from MRI Protection Mode). After exit from MRI Protection Mode, check system integrity by running lead impedance, pacing threshold, and intrinsic amplitude tests.

For RESONATE HF, RESONATE, PERCIVA HF, PERCIVA, CHARISMA, and VIGILANT devices, on exit from MRI Protection Mode, a summary report of the MRI is stored as an MRI episode and can be printed as an episode report. A sample report printout is shown in Figure D–3 Sample stored event detail printout on page D-2. The MRI Protection episode can also be accessed and viewed via the Arrhythmia Logbook. The MRI episode can also be viewed on the Arrhythmia Logbook via remote patient monitoring (if available).

Time-out (automatic) Exit from MRI Protection Mode

If the MRI Protection Mode Time-out parameter was programmed to a value other than Off, the pulse generator will exit MRI Protection Mode automatically after the selected number of hours, and the system will return to previously programmed settings (except for the Beeper and Minute Ventilation as described below).

Manual Exit from MRI Protection Mode

Alternatively, if the Time-out feature was programmed Off, or any time manual cancellation of MRI Protection Mode is desired, the PRM is used to take the pulse generator out of MRI Protection Mode.

Do not leave the pulse generator in MRI Protection Mode any longer than necessary following the scan. To manually exit MRI Protection Mode, perform the following steps:

a. Interrogate the pulse generator using the wand (RF telemetry is disabled in MRI Protection Mode).
b. Select the Exit MRI Protection Mode button from the MRI Protection Programmed screen (Figure 2–10 MRI Protection Programmed dialog on page 2-13).

**NOTE:** If necessary, STAT PACE, STAT SHOCK, or DIVERT THERAPY can also be used to exit MRI Protection Mode. STAT PACE will initiate STAT PACE pacing parameters (see the pulse generator’s Reference Guide for more information about STAT PACE).

2. Evaluate Device

Following user-initiated cancellation of MRI Protection Mode, the PRM will automatically navigate to the Lead Tests screen and prompt the user to perform lead tests (Figure 2–11 MRI Protection Exited dialog on page 2-13).

Perform the following lead measurements and evaluate the results:

- Intrinsic Amplitude
- Lead Impedance
- Pace Threshold

Figure 2–10. MRI Protection Programmed dialog

Figure 2–11. MRI Protection Exited dialog
Perform these tests subsequent to automatic (Time-out) exit from MRI Protection Mode as well. When testing is complete, it is recommended that the PRM be used to save all patient data.

Upon exit from MRI Protection Mode, whether automatically or manually, all parameters are immediately restored to pre-MRI Protection Mode values with the following exception(s):

a. Restoration of function of the Minute Ventilation sensor is delayed upon exit from MRI Protection Mode. If MV is programmed to On or Passive at the time of entry into MRI Protection Mode, upon exit from the mode, an automatic six-hour calibration of the sensor will begin. MV-driven rate response is not available during this calibration period. If MV-driven rate response is desired sooner, a manual calibration can be performed. Manual calibration is completed in five minutes or less. For additional information about MV calibration, see the Reference Guide for the pulse generator.

b. The Beeper will remain Off upon exiting MRI Protection Mode. If desired, the user can manually attempt to reenable the Beeper (Figure 2–12 Configure Beeper Settings screen on page 2-14).

The Configure Beeper Settings option will only be available after the device is programmed into MRI Protection Mode. When the Beeper is programmed back On, all programmable and non-programmable Beeper features will be reverted to their nominal values.

Perform the following steps to program the Beeper:

i. Select the Settings tab.

ii. Select the Beeper tab.

iii. Select the desired value for the Beeper.

Coming into contact with the strong magnetic field of an MRI scanner causes a permanent loss of the Beeper volume. After reenabling the Beeper, ensure it is still audible by placing a magnet over the device and listening for beeps. If the Beeper is audible, leave the Beeper On. If the Beeper is not audible, program the Beeper to Off.
CARDIOLOGY CHECKLIST FOR THE IMAGEREADY DEFIBRILLATION SYSTEM

APPENDIX A

This appendix is provided for convenience. Refer to the remainder of this Technical Guide for the full list of Warnings and Precautions and complete instructions for using the ImageReady Defibrillation System.

Conditions of Use – Cardiology

The following Conditions of Use must be met in order for a patient with an ImageReady Defibrillation System to undergo an MRI scan.

☐ Patient is implanted with an ImageReady MR Conditional Defibrillation System (*ImageReady Defibrillation System Components for 1.5 T* on page C-1).

☐ No other active or abandoned implanted devices, components or accessories present such as lead adaptors, extenders, leads or pulse generators.

☐ Pulse generator in MRI Protection Mode during scan.

☐ As soon as MRI Protection Mode is programmed, the patient must be continuously monitored by pulse oximetry and electrocardiography (ECG). Ensure backup therapy is available (external rescue).

☐ Patient is judged to be clinically capable of tolerating no Tachycardiaprotection for the entire duration in which the pulse generator is in MRI Protection Mode.

☐ Patient does not have elevated body temperature or compromised thermoregulation at time of scan.

☐ Pulse generator implant location restricted to left or right pectoral region.

☐ At least six (6) weeks have elapsed since implantation and/or any lead revision or surgical modification of the MR Conditional Defibrillation System.

☐ No evidence of a fractured lead or compromised pulse generator-lead system integrity.

Scanning Procedure

Pre-scan

1. Ensure patient meets all Cardiology Conditions of Use for MRI scanning (see left column).

2. Exposure to MRI scanning causes a permanent loss of the Beepervolume. The physician and patient should weigh the benefit of the MR procedure against the risk of losing the Beeper.

3. Ensure that the HCPs involved in performing the MRI scan have received the model numbers of the pulse generator and lead(s) implanted in the patient.

4. As close to the start of the scan as possible, program the pulse generator into MRI Protection Mode and begin continuous monitoring of the patient.

5. Print the MRI Protection Settings Report, place it in the patient’s file, and provide to radiology personnel.
   • The report documents MRI Protection Mode settings and details. If the Time-out feature is used, the report includes the exact time and date when MRI Protection Mode will expire.

During Scan

6. Ensure the patient is continuously monitored by pulse oximetry and electrocardiography (ECG), with backup therapy available (external rescue), while the device is in MRI Protection Mode.

After scan

7. Ensure the pulse generator is returned to pre-MRI operation, either automatically if the Time-out parameter was set, or manually using the PRM. Perform follow-up testing of the defibrillation system after exiting MRI Protection Mode, and continue patient monitoring until the pulse generator is returned to pre-MRI operation.

8. The Beeper will remain OFF upon exiting MRI Protection Mode.

WARNING: Unless all of the MRI Conditions of Use are met, MRI scanning of the patient does not meet MR Conditional requirements for the implanted system, and significant harm to or death of the patient and/or damage to the implanted system may result.

WARNING: Use caution when programming MRI Protection Mode in pacing-dependent patients who have high right atrial and right ventricular pacing thresholds on the paced lead(s) (> 2.0 V). The maximum pacing amplitude in MRI Protection Mode is 5.0 V, which may limit the available pacing amplitude safety margin for patients with high pacing thresholds. Failure to maintain sufficient pacing amplitude safety margin may result in loss of capture.

WARNING: The risk of arrhythmia may be increased with asynchronous pacing (AOO, VOO, DOO). When programming asynchronous pacing during MRI Protection Mode, select a pacing rate that avoids competitive pacing and minimize the time in MRI Protection Mode.

WARNING: If the MRI Protection Time-out value is programmed to Off, the patient will not receive Tachycardia therapy, and the pacing options are limited to Off or Asynchronous until the pulse generator is programmed out of MRI Protection Mode and back to normal operation.
**WARNING:** The Programmer/Recorder/Monitor (PRM) is MR Unsafe and must remain outside the MRI site Zone III (and higher) as defined by the American College of Radiology Guidance Document for Safe MR Practices. Under no circumstances should the PRM be brought into the MRI scanner room, the control room, or the MRI site Zone III or IV areas.

**WARNING:** The Beeper will no longer be usable following an MRI scan. Coming in contact with the strong magnetic field of an MRI scanner causes a permanent loss of the Beeper volume. This cannot be recovered, even after leaving the MR scan environment and exiting MRI Protection Mode. Before an MRI procedure is performed, a physician and patient should weigh the benefit of the MR procedure against the risk of losing the Beeper. It is strongly recommended that patients are followed on LATITUDE NXT after an MRI scan if they are not already. Otherwise, an in-clinic follow-up schedule of every three months is strongly recommended to monitor device performance.

This appendix is provided for convenience. Refer to the remainder of this Technical Guide for the full list of Warnings and Precautions and complete instructions for using the ImageReady Defibrillation System.

**Conditions of Use – Radiology**

The following Conditions of Use must be met in order for a patient with an ImageReady Defibrillation System to undergo an MRI scan.

- MRI magnet strength = 1.5 T only
- RF field = Approximately 64 MHz
- Maximum spatial gradient = 50 T/m (5,000 G/cm)
- MRI equipment specification = Horizontal, 1H proton, closed bore scanners only
- Specific Absorption Rate (SAR) limits for the entire active scan (Normal Operating Mode\(^a\)):
  - Whole body averaged, ≤ 2.0 watts/kilogram (W/kg)
  - Head, ≤ 3.2 W/kg
- Maximum specified gradient slew rate ≤ 200 T/m/s per axis
- There are no restrictions for positioning the defibrillation system within the integrated body coil of the MRI scanner. The use of receive-only coils is not restricted. Local transmit-only coils or local transmit/receive coils may be used, but should not be placed directly over the defibrillation system.
- Patient in supine or prone position only.
- Patient must be continuously monitored by pulse oximetry and electrocardiography (ECG) for the entire duration in which the pulse generator is in MRI Protection Mode. Ensure backup therapy is available (external rescue).

\(^a\) As defined in IEC 60601-2-33, 201.3.224, 3rd Edition.

**Scanning Procedure**

**Pre-scan**

1. Ensure Cardiology has cleared the patient for scanning eligibility based on the Cardiology MRI Conditions of Use ("Cardiology Checklist for the ImageReady Defibrillation System” on page A-1)
2. As close to the start of the scan as possible, the patient's pulse generator is programmed into MRI Protection Mode and continuous monitoring of the patient begins.
3. Refer to the MRI Protection Settings Report to confirm that the patient's device is in MRI Protection Mode. If the Time-out feature is used, the report includes the exact time and date when MRI Protection Mode will expire. **Verify that adequate time remains to complete the scan.**

**During Scan**

4. Ensure the patient is continuously monitored by pulse oximetry and electrocardiography (ECG), with backup therapy available (external rescue), while the device is in MRI Protection Mode.

**After scan**

5. Ensure the pulse generator is returned to pre-MRI operation, either automatically if the Time-out parameter was set, or manually using the PRM. Perform follow-up testing of the defibrillation system after exiting MRI Protection Mode, and continue patient monitoring until the pulse generator is returned to pre-MRI operation.

**WARNING:** Unless all of the MRI Conditions of Use are met, MRI scanning of the patient does not meet MR Conditional requirements for the implanted system, and significant harm to or death of the patient and/or damage to the implanted system may result.

**WARNING:** The Programmer/Recorder/Monitor (PRM) is MR Unsafe and must remain outside the MRI site Zone III (and higher) as defined by the American College of Radiology Guidance Document for Safe MR Practices\(^1\). Under no circumstances should the PRM be brought into the MRI scanner room, the control room, or the MRI site Zone III or IV areas.

**CAUTION:** The presence of the implanted defibrillation system may cause MRI image artifacts.

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Only specific combinations of pulse generators and leads constitute an ImageReady Defibrillation System that is valid for use with 1.5 T scanners.

### ImageReady MR Conditional Defibrillation System Components for 1.5 T

<table>
<thead>
<tr>
<th>Component</th>
<th>Model Number(s)</th>
<th>MR Status</th>
<th>1.5 T</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pulse Generators</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUTOGEN MINI ICD</td>
<td>D044, D046</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>AUTOGEN EL ICD</td>
<td>D174, D176</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>AUTOGEN X4 CRT-D</td>
<td>G179</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>CHARISMA X4 CRT-D</td>
<td>G337, G347</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>CHARISMA EL ICD</td>
<td>D332, D333</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>DYNAGEN MINI ICD</td>
<td>D020, D022</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>DYNAGEN EL ICD</td>
<td>D150, D152</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>DYNAGEN X4 CRT-D</td>
<td>G158</td>
<td>MR Conditional</td>
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<tr>
<td>INOGEN MINI ICD</td>
<td>D010, D012</td>
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<tr>
<td>INOGEN EL ICD</td>
<td>D140, D142</td>
<td>MR Conditional</td>
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<td>INOGEN X4 CRT-D</td>
<td>G148</td>
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<td>ORIGEN MINI ICD</td>
<td>D000, D002</td>
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<td>ORIGEN X4 CRT-D</td>
<td>G058</td>
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<tr>
<td>PERCIVA HF ICD</td>
<td>D512, D513</td>
<td>MR Conditional</td>
<td>X</td>
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<tr>
<td>PERCIVA ICD</td>
<td>D412, D413</td>
<td>MR Conditional</td>
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<tr>
<td>RESONATE HF CRT-D</td>
<td>G537, G547</td>
<td>MR Conditional</td>
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<tr>
<td>RESONATE HF ICD</td>
<td>D532, D533</td>
<td>MR Conditional</td>
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<td>RESONATE X4 CRT-D</td>
<td>G437, G447</td>
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<td>RESONATE EL ICD</td>
<td>D432, D433</td>
<td>MR Conditional</td>
<td>X</td>
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<td>VIGILANT X4 CRT-D</td>
<td>G237, G247</td>
<td>MR Conditional</td>
<td>X</td>
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<tr>
<td>VIGILANT EL ICD</td>
<td>D232, D233</td>
<td>MR Conditional</td>
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<tr>
<td><strong>Leads and Accessories</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FINELINE II Sterox Pacing Leads</td>
<td>4479, 4480</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>FINELINE II Sterox EZ Pacing Leads</td>
<td>4469, 4470, 4471, 4472, 4473, 4474</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>Suture Sleeves for FINELINE II leads</td>
<td>6220, 6221</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>INGEVITY MRI Pacing Leads (Tined Fixation)</td>
<td>7735, 7736</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>INGEVITY MRI Pacing Leads (Extendable/Retractable Fixation)</td>
<td>7740, 7741, 7742</td>
<td>MR Conditional</td>
<td>X</td>
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<tr>
<td>Suture Sleeve for INGEVITY MRI leads</td>
<td>6402</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>IS-1 Lead Port Plug</td>
<td>7145</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>ENDOTAK RELIANCE (DF4) Defibrillation Leads</td>
<td>0262, 0263, 0265, 0266, 0272, 0273, 0275, 0276, 0282, 0283, 0285, 0286, 0292, 0293, 0295, 0296</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>Device Description</td>
<td>Component Numbers</td>
<td>Condition</td>
<td>MR Conditional</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>-------------------</td>
<td>--------------</td>
<td>----------------</td>
</tr>
<tr>
<td>RELIANCE 4-FRONT (DF4) Defibrillation Leads</td>
<td>0636, 0650, 0651, 0652, 0653, 0654, 0655, 0657, 0658, 0662, 0663, 0665, 0672, 0673, 0675, 0676, 0682, 0683, 0685, 0686, 0692, 0693, 0695, 0696</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>Suture Sleeve for RELIANCE 4-FRONT leads</td>
<td>6403</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>ACUITY X4 (IS4) Pacing Leads</td>
<td>4671, 4672, 4674, 4675, 4677, 4678</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>Suture Sleeve for ACUITY X4 leads</td>
<td>4603</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>IS4/DF4 Lead Port Plug</td>
<td>7148</td>
<td>MR Conditional</td>
<td>X</td>
</tr>
<tr>
<td>ZOOM LATITUDE Programmer/Recorder/Monitor (PRM) and PRM Software Application</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZOOM LATITUDE PRM</td>
<td>3120</td>
<td>MR Unsafea</td>
<td>N/A</td>
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<tr>
<td>ZOOM LATITUDE PRM Software Application</td>
<td>2868</td>
<td>N/A</td>
<td>N/A</td>
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</table>

a. See PRM is MR Unsafe Warning regarding the PRM.
Twenty-four hour time format is used. Measurement Date column indicates the date the Leads Data were collected, which may be prior to the date of the MRI Protection Settings Report itself.

Figure D–1. Sample MRI Protection Settings Report printout with Time-out set to 6 hours (Pages 1–2)
**MRI Protection Status**

MRI Protection Mode: **On**

MRI Protection Entry Time: 10 Apr 2017 12:36

⚠️ MRI Protection will stay "On" until reprogrammed by a trained professional.

**Settings During MRI Protection**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Old Value</th>
<th>New Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brady Mode</td>
<td>DDD</td>
<td>DOO</td>
</tr>
<tr>
<td>Lower Rate Limit</td>
<td>45 min⁻¹</td>
<td>65 min⁻¹</td>
</tr>
<tr>
<td>AV Delay</td>
<td>180 - 180 ms</td>
<td>100 ms</td>
</tr>
<tr>
<td>Ventricular Pacing Chamber</td>
<td>BIV</td>
<td>BIV</td>
</tr>
<tr>
<td>Pacing Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrial</td>
<td>3.5 V @ 0.4 ms</td>
<td>5.0 V @ 1.0 ms</td>
</tr>
<tr>
<td>Right Ventricular</td>
<td>3.5 V @ 0.4 ms</td>
<td>5.0 V @ 1.0 ms</td>
</tr>
<tr>
<td>Left Ventricular</td>
<td>3.5 V @ 0.4 ms</td>
<td>3.5 V @ 0.4 ms</td>
</tr>
</tbody>
</table>

Page 1 of 4

**Figure D–2. Sample MRI Protection Settings Report printout with Time-out set to Off (Page 1)**

**Event MRI-5: 10 Apr 2017 12:34**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tachy Mode</td>
<td>Off</td>
<td></td>
</tr>
<tr>
<td>Brady Mode</td>
<td>DOO</td>
<td></td>
</tr>
<tr>
<td>Lower Rate Limit</td>
<td>65 min⁻¹</td>
<td></td>
</tr>
<tr>
<td>AV Delay</td>
<td>100 ms</td>
<td></td>
</tr>
<tr>
<td>Ventricular Pacing Chamber</td>
<td>BIV</td>
<td></td>
</tr>
<tr>
<td>Pacing Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atrial</td>
<td>5.0 V @ 1.0 ms</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Right Ventricular</td>
<td>5.0 V @ 1.0 ms</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Left Ventricular</td>
<td>3.5 V @ 0.4 ms</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>LV Offset</td>
<td>0 ms</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>MRI Protection Time-out</td>
<td>6 h</td>
<td>10 Apr 2017</td>
</tr>
</tbody>
</table>

**Leads Data (most recent pre-MRI scan measurements)**

<table>
<thead>
<tr>
<th>Lead</th>
<th>Amplitude</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>Atrial</td>
<td>2.3 mV</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Pace Impedance</td>
<td>548 Ω</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Pace Threshold</td>
<td>1.8 V @ 0.4 ms</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Right Ventricular</td>
<td>4.3 mV</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Pace Impedance</td>
<td>548 Ω</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Pace Threshold</td>
<td>1.4 V @ 0.4 ms</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Left Ventricular</td>
<td>4.2 mV</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Pace Impedance</td>
<td>311 Ω</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Pace Threshold</td>
<td>1.5 V @ 0.4 ms</td>
<td>10 Apr 2017</td>
</tr>
<tr>
<td>Shock</td>
<td>Impedance</td>
<td>47 Ω</td>
</tr>
</tbody>
</table>

**MRI Protection Exit Status**

User Terminated

**MRI Protection Exit Time**

10 Apr 2017 12:35

**Event Ended** 00:00:52

For RESONATE HF, RESONATE, PERCIVA HF, PERCIVA, CHARISMA, and VIGILANT devices

**Figure D–3. Sample stored event detail printout**
SYMBOLS ON PACKAGING

APPENDIX E

The following symbols may be used on packaging and labeling.

Table E–1. Symbols on Packaging

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU0086</td>
<td>CE mark of conformity with the identification of the notified body authorizing use of the mark</td>
</tr>
<tr>
<td>EC REP</td>
<td>Authorized Representative in the European Community</td>
</tr>
<tr>
<td></td>
<td>Manufacturer</td>
</tr>
<tr>
<td></td>
<td>MR Conditional</td>
</tr>
<tr>
<td>REF</td>
<td>Reference number</td>
</tr>
</tbody>
</table>
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