Diasensor® 1000 Non-Invasive Blood Glucose Monitor
Design Requirements
Program No. 51

1. Table of Contents

2. Product Functional Requirements

2.1 Maintainability Requirements

- This product's continuing satisfactory performance will depend on the user cleaning the probe at prescribed times during, before, and/or after data acquisition in accordance with specified procedure.
- Bicontrol Technology service personnel will perform all otherwise required maintenance as prescribed in procedures.

2.2 Operational Requirements

2.2.1 Intended Use

- The *Diasensor 1000* is intended for use primarily by insulin requiring patients with Type I and Type II diabetes to monitor their blood glucose concentration. It is not intended for diagnostic or screening purposes. Physicians should evaluate patients younger than ten (10) years of age for their capability to perform the necessary tasks associated with the use of the Diasensor 1000.
- Only physicians, not patients, use the *Diasensor 1000* data to adjust patient's therapeutic regimen.
- The *Diasensor 1000* is not intended for use by patients during pregnancy, on peritoneal dialysis or hemodialysis, or with decompensated congestive heart failure.
- Each patient purchasing a *Diasensor 1000* must undergo a calibration procedure. In this process, instrument data are collected simultaneously with glucose level information from known invasive glucose detectors like *YSI* or *HemoCue*. Once data are collected, the calibration vector is built by means of linear regression. The calibration vector is later used to measure glucose value on the basis of readings. Up to four (4) patients may be calibrated and use a single *Diasensor 1000.*
- The *Diasensor 1000* Physician's Guide and the *Diasensor 1000* User's Manual describe the calibration procedure.
- The *Diasensor 1000* will provide information to determine an average daily glucose level and standard deviation for a thirty (30) day period at given daily patient conditions (fasting, etc.). The average will satisfy an acceptance criteria of equivalence of means and variances tests at a 95% significance level.

2.2.2 Validation

- Validate the *Diasensor 1000* in a clinical trial.

2.3 Quality Requirements

- Manufacturing process will assure the *Diasensor 1000* is free from defects and meets all product specifications.

2.4 Repairability Requirements

- Bicontrol Technology service or manufacturing personnel will perform all repairs.
- Bicontrol Technology service personnel will perform all service activities.
- The product design of the *Diasensor 1000* will readily allow internal access to perform unit service and repair. Engineering will minimize the use of fasteners and captivation of assemblies or components that are serviceable.

- Provide applicable service documentation and training to support repair and servicing activities.

3. Product Performance Requirements

3.1 Durability Requirements

- The *Diasensor 1000* should be capable of transport via automobile trunk, truck cargo space, air plane overhead compartment, or other normal vibration and shock producing customer transportation methods.

3.2 Environmental Requirements

3.2.1 General

Parameter	Limits	Units	Comments
Storage Temperature	-20 to 60	°C	
	-4 to 140	°F	
Operating Temperature	16 to 26	°C	
	60 to 80	°F	
Storage Humidity	90 max.	%	non-condensing relative
Operational Humidity	90 max.	%	non-condensing relative

3.2.2 EMC Requirements

Parameter	Limits Per
Conducted Emissions	MIL-STD-461D*
EMC Field Exposure	IEC 60601-1-2
	EN 55011 Class B Group 1
Electromagnetic Compatibility	EN 50081-1
ESD (susceptibility)	IEC 801-2, EN 50082
Leakage Current	IEC 60601-1
Magnetic Field	MIL-STD-461D (RE101)*
Magnetic Field Immunity	MIL-STD-461D*

*FDA requirements

3.3 Performance Requirements

3.3.1 Audible noise

- The device will not generate more than 50 dBA of noise (due to motors and fans).

3.3.2 Data Acquisition

- The device will be capable of measuring reference spectra.
- The device will be capable of measuring control standard spectra.
- The device will be capable of measuring diffuse reflective skin spectra.
- The device will be capable of measuring dark spectra.
- The device will be capable of detecting a dirty probe surface.

- The device will be capable of detecting the absence or removal of the user's arm from the probe surface when collecting skin spectra.

3.3.3 Electrical Requirements

3.3.3.1 General

Parameter	Nom	Units	Limits
Input Requirements	100	Volts AC	90-110
	110	Volts AC	99-122
	120	Volts AC	108-132
	220	Volts AC	198-242
	230	Volts AC	207-253
	240	Volts AC	216-264
Frequency	50/60	Hz	+/-2%
Total Power	200 max.	Watts	

3.3.3.2 Fuses

- The device will be fused at each side of the mains with a 5 x 20 mm Slo-Blo type per IEC 127-2, Sheet III fuse.

3.3.3.3 Warm-up

- Warm-up period will be no more than three (3) hours before beginning any monitoring sessions to allow the device to stabilize after turning on the unit. The device may remain on at all times.

3.3.4 Electronics Requirements

3.3.4.1 Central Processing Unit

- The device will contain a programmable central processing unit (CPU). The CPU will be used to control the overall operation of the device, including data acquisition, electromechanical components, user interfaces, and communications interfaces. In addition, the CPU will be used to compute the user's blood glucose concentration level from the spectral data.

3.3.4.2 Memory

- There will be a minimum read-only memory program storage capacity of 256K bytes.
- There will be a minimum read/write data storage capacity of 256K bytes.
- There will be a minimum read-only data storage capacity of 256K bytes in addition to the read/write data storage.

3.3.4.3 Real-Time Clock

- The device will contain a real-time clock (RTC). The RTC will be used to associate a specific date and time to glucose measurements.
- The RTC will be capable of continued operation in the absence of AC line power.

3.3.5 Input Requirements

- The data set collected during calibration constitutes input to the instrument.

- The *Diasensor 1000* will be capable of calibration to an individual diabetic.

3.3.6 Instrument Acceptance Criteria

- Each device offered for sale will pass a final test per a product test specification
- Additionally, verify each instrument for its full functionality at the end of the manufacturing process.

3.3.7 Measurement Technique

- The device will use infrared spectrophotometry in the range of 1100 to 2100 nm to perform glucose measurement. This technique involves the conversion of infrared light at into electrical signals which are then processed to obtain information about the chemical constituents of an observed sample.
- The infrared spectrophotometry measurement process will be noninvasive.
- At a minimum, a spectrum will consist of an array of infrared energy measurements centered at various wavelengths in the range of 1100 to 2100 nm, along with a time stamp indicating the time of collection.

3.3.8 Mechanical Requirements

3.3.8.1 General

- The device will be a desktop unit with a power supply that is removable (two separate units) and a six foot cable to connect the power supply to the base unit.
- Base unit 30 pounds max.
- Power supply 15 pounds max.
- Black box size 24 inches x 10 inches x 16 inches max. (with the power supply attached)

3.3.8.2 Arm Tray

- The device will contain an arm tray mechanism capable of repositioning a user's arm over the probe during glucose measurement.
- The arm tray will be capable of operating with an applied force up to ten (10) pounds evenly distributed.
- The arm tray will be designed to be reversible so that either the right or left arm may be used for glucose measurement.
- The arm tray will have an adjustable length (outside to outside) between 13 inches and 18 inches.
- The sampling of arm sites will be accomplished by a section of the support around the probe and the entire arm tray moving horizontally, in steps. Horizontal motion range will be a total travel of 0.96 ± .03 inches.
- The probe will protrude 0.06 in. nominal above the lowest point of the arm tray.

3.3.9 Modes of Operation

- There are three modes of operation: Calibration, Glucose Measurement, and Test and Diagnostics.
- The device will be capable of recognizing the mode of operation without requiring the user to make a selection.

3.3.9.1 Calibration Mode

The following requirements apply only to the calibration mode of operation.

- The device will be capable of operation in calibration mode. Calibration mode is used to record spectra over a range of glucose levels. The calibration spectra will be processed to obtain a set of parameters for the device/user combination used for computing blood glucose concentration level. The processing of spectra resulting in the generation of glucose measurement parameters may be performed external to the device.
- The device will be capable of transferring spectra to an external data storage device.

3.3.9.2 Glucose Measurement Mode

The following requirements are applicable only to the glucose measurement mode of operation.

- The device will be capable of operation in glucose measurement mode. The glucose measurement mode is used to collect and process spectra in real-time to determine blood glucose concentration levels.
- The device will provide the measured glucose concentration in units of milligrams per deciliter (mg/dL) or milimoles per liter (mmol/L).
- The device will be capable of recording each glucose measurement. The measurement record will include a user identifier, measurement date and time, and measured glucose concentration level.
- A single glucose measurement will not exceed two (2) minutes, measured from the time the user initiates the process from the device keypad until the time a measurement is provided to the user.
- The monitor will be capable of displaying a glucose range from 0 to 500 mg/dL.
- The device will compute and display blood glucose concentration based on acquired spectra upon the successful completion of the measurement cycle.
- The device will record glucose measurements on the user memory card.
- The glucose measurement process will be able to perform statistical calculations using data from skin spectra.
- The glucose measurement process will contain provisions for detecting and rejecting measurements considered out of range (either too high or too low).

3.3.9.3 Test and Diagnosis

The Test and Diagnosis mode is for internal use to allow use of the capabilities of the device for diagnostic and development applications.

- The device will be able to capture and store raw spectral data.
- The device will be able to interface with external computing devices.
- The device will be able to transfer data to the PCMCIA card.
- The device will be able to transfer data to an external device.

3.3.10 Noise

- Total system noise will be less than 200 μAU calculated on the basis of 600 reference spectra collected during approximately 7.5 minutes.
- Drift corrected short term noise will be less than 5 μAU.

3.3.11 Optical Requirements

3.3.11.1 Light Source

- The device will contain a tungsten lamp.

3.3.11.2 Light Path and Probe

- The device will contain a probe designed for intimate contact with the user's skin during glucose measurement.
- The light path and probe will contain both a transmit path and a receive path. The probe will be capable of transmitting energy for diffusion into the user's skin, and receiving reflected energy from the skin constituents.
- The total power of the infrared energy at the skin surface will not exceed 200 mW.
- The probe surface will be temperature stabilized at 35 °C ± 2°C.
- The probe surface will not contain any material biologically reactive with skin.

3.3.11.3 Spectrograph

- The device will contain a spectrograph capable of converting infrared energy to electrical signals.

3.3.12 Performance in Applications

- The *Diasensor 1000* will provide information to determine an average daily glucose level and standard deviation for a thirty (30) day period at given daily patient conditions (fasting, etc.). The average will satisfy an acceptance criteria of equivalence of means and variances tests at a 95% significance level.
- The minimum glucose measurement range will be 80 mg/dL to 400 mg/dL.

3.3.13 Control Sample and Reference Requirements

3.3.13.1 Control Sample

- Control Standard material will produce a spectra which would have a spectral correlation coefficient to a typical skin spectra better than 0.9.

3.3.13.2 Measurement Cycle

- Reference and Control Sample measurements will be taken at the start up of each measurement cycle before the arm is placed on the device. The Reference and Control Sample mechanism will move between the reference/control sample position to the stow position within five (5) seconds.

3.3.13.3 Reference Reproducibility

- Total reference non-reproducibility will be less than 100 μAU.
- Baseline corrected reference non-reproducibility will be less than 40 μAU.

3.3.13.4 Reference Sample

- The distance from the probe to the reference during referencing will be 0.50 inches ± 0.1 inches.
- Spectralon will be used as a reference material.
- In the rest position, the reference mechanism should be over the probe, with the probe light illuminating the reference material.

3.3.14 Wavelength Stability

- The device will be less than 0.1 nm per °C for uniform ambient temperature change over the operating temperature range.

3.4 Reliability Requirements

- The *Diasensor 1000* should have a useful service life of seven (7) years with normal servicing and maintenance.

3.5 Safety Risk Management Requirements

- Perform Risk Analysis on the *Diasensor 1000* system in accordance with Biocontrol procedures.
- Use a control standard and/or other self diagnostic techniques for fail safe purposes to determine customer usability of the *Diasensor 1000*.
- Vigilance observations in accordance with Biocontrol procedures, numbers QA023-SP (Quality System Report to Senior Management) and CS002-SP (Customer Complaint Processing)
- *Diasensor 1000* risk criteria are as follows:
  - User will not incur direct physical harm from use of the instrument nor from conditions arising from foreseeable misuse of the instrument.
  - User will incur no more risk for diabetes therapy using the *Diasensor 1000* than would be incurred using invasive glucose measurement techniques.
- Upon recognition of a failure, the *Diasensor 1000* will return an error message to the user, and suspend the glucose measurement.
- Usage of safety mechanisms, product warnings, and product labels to reduce product use hazards shall be to an acceptable level and in accordance with the risk criteria.
- Adequate operator and caregiver safety instructions will be included in manuals and on the labeling supplied with the unit.

4. Product Interface Requirements

4.1 Customer Interface Requirements

4.1.1 General

- The customer will be capable of using the *Diasensor 1000* in their home environment during calibration, verification, and measurement with a minimum of training. Use of the product should not require specialized equipment or skills not normally available to a diabetic user.
- Each product user will undergo a calibration and a calibration verification cycle before using the instrument for glucose measurement.
- Product users will be provided with a means of verifying the quality of measurements on a regular basis. If the quality of a measurement does not meet the predetermined acceptance criteria, there will be a means of re-calibrating the instrument.
- An acceptable invasive glucose monitoring device will be used as the standard for quality checks and measurement acceptance criteria.
- The *Diasensor 1000* will be capable of a functional self-checks before and during measurement by means of an internal standard and internal reference.
- The *Diasensor 1000* will be validated by a clinical trial.

4.1.2 Beeper

- The device will contain an audible beeper capable of prompting and/or alerting the user when some action is required.

4.1.3 Display

- The device will contain a display capable of displaying a minimum of three lines of text of a height of at least 0.2 inches (approximately 14-point text).
- The display will be readable under all ambient light conditions.
- The device will contain a manual brightness control.

4.1.4 Keypad

- The device will include a keypad containing a minimum of four selection buttons and a separate start button. The user should be able to select from a group of four choices by pressing a single button.

4.1.5 User Memory Card Port

- The device will contain a port capable of accepting a PCMCIA Type I memory card.
- The device will be capable of reading data from a memory card in the user memory card port.
- The device will be capable of writing data to a memory card in the user memory card port.
- The device will be able to determine if there is a card present and alert the user if there is no card in the port.

4.2 External Interface Requirements

- The device will contain a serial port capable of communications with an attached data storage device.
- The serial port electrical interface will be RS-232 with a DB-9 connector.

- The device will be capable of serial port communications at a minimum baud rate of 19200 baud.

4.3 Labeling Requirements

- Manuals and labels will conform to both European Community and FDA requirements. There will be adequate safety required labels per 93/42 EEC MDD and Title 21 CFR 820. Warnings will be identified and explained in the user manual.

4.3.1 Shipping Labels

- The packaging will include all applicable shipping labels require for the intended destination.

4.3.2 User Manual

- There will be a user's manual.

4.3.3 Warning Labels

- The device will have all the applicable warning labels required for the intended destination. All labels will be explained in the User's Manual.

4.4 Service Delivery Requirements

- Deliver required service (data collection, calibration installation, etc.) in such a manner that once installed in the home environment, the customer will not have to return the instrument to a service center except for maintenance or repairs.
- Provide a comprehensive physician's guide to the prescribing physician and a user's manual for the customer.
- A computer may be used for service delivery.

5. Product System and Program Requirements

5.1 Business Risk Management Requirements

5.1.1 Development Risks

- Initiate foreign sales or receive FDA approval by first quarter of 1998.

5.1.2 Market Risks

5.1.2.1 Competition

- Hire the necessary talent and organize the company to facilitate the development of the glucose sensor.

5.1.2.2 Customer

- Develop marketing plan focusing on painless monitoring and comparison of the cost of non-invasive versus invasive glucose monitoring.
- Develop plans for the customer to purchase or lease the monitor to ease the effects of its high initial cost.
- Reduce initial product cost of the instrument by 40% during the first year after introduction.

5.2 Customer Service and Product Support Requirements

- Train the customer in use of the *Diasensor 1000* at time of delivery.
- Calibrate the user in the home.
- Collect calibration data from the home.
- Collect screening evaluation data from the home.
- Biocontrol Technology will provide necessary product support activities.

5.3 Financial Requirements

- Initial product manufacturing cost must be no more than US$ 10,000 (direct labor, materials, overhead) per delivered unit at low volume (less than 100 units a month).

5.4 Manufacturability Requirements

- Manufacturability for the *Diasensor 1000* may be defined as "It is possible to assemble", and "It is possible to find vendors to supply required components"

5.5 Manufacturing Requirements

- Initial production volume must be at least 25 instruments per month for the first six (6) months of production (following pilot production).

5.6 Marketing Requirements

- First priority is to develop foreign markets. Select a viable geographic market and concentrate on compliance and approval to sell in that market.
- Receive EC and FDA approval as soon as possible.

5.7 Packaging Requirements

- Package the primary instrument unit and its power supply separately to accommodate variations in requirements due to user's geographic location.

- Include all additional materials and support components in additional packaging as required.
- Marketing will establish visual package criteria (graphics, labels).
- Design packaging capabilities for individual or palletized shipment.

5.8 Regulatory Compliance Requirements

- Achieve regulatory compliance in three (3) markets:
- - Domestic
- - European Community
- - Far East
- Biocontrol Applications Engineering will provide liaison to the FDA for 510K compliance.
- Use the FDA 510K reviewer's guidance manual as a reference for preparing 510K.
- Achieve European Community compliance under MDD 93/42/EEC.

5.9 Shipping Requirements

- The device will be packaged in such a manner to withstand normal shipping and handling by commercial modes of transport, in accordance with ISTA Procedure 1A.

5.10 Standards Compliance Requirements

- Use IEEE standards, Military Standards, or others where appropriate.

5.11 Statutory Compliance Requirements

- Requirements may vary according to geographic location of sales.

5.12 Testability Requirements

- Biocontrol Technology service, manufacturing, or approved vendor personnel perform all unit and component testing.
- Design the *Diasensor 1000* to allow ready access for unit testing. Minimize inaccessibility of assemblies or components requiring unit assembly testing.
- Validate performance of components and subsystems to the extent possible to minimize production testing requirements.

6. References

CS002-SP	Customer Complaint Processing
EG008-SP	Risk Analysis Development
PM002-SP	Preparation of a Design Requirements Document
PM003-SP	The Program Management Cycle
QA023-SP	Quality System Report to Senior Management
ISTA Procedure 1A	Pre-shipment Test Parameters, Procedure 1A For Testing Packaged-Products Weighing Under 100 Pounds
21 CFR 820	Medical Devices; Current Good Manufacturing Practice Final Rule; Quality System Regulation (1996)
EN50011	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment-1991
IEC 127-2	Cartridge Fuse Link, Sheet III specification for Time Lag Fuses
IEC 801-2	Electromagnetic compatibility for industrial-process measurement and control equipment Part 2: Electrostatic discharge requirements - 1991
MDD 93/42 EEC	EC Council Directive Concerning Medical Devices (1993)
MIL-STD-461D	Electromagnetic Interference Emissions and Susceptibility