

Method to Detect Skin Irritation of Medical Device Extracts using Reconstructed human Epidermis (RhE).

Test using EpiDerm™ RhE

MatTek Corporation

In accordance with:

International Standards Organization
ISO 10993-23:2021

IN VITRO SKIN IRRITATION TEST FOR MEDICAL DEVICE
EXTRACTS

Table of Contents

1. RATIONALE AND BACKGROUND.....	3
2. SPECIFIC PURPOSE OF THE METHOD.....	4
3. BRIEF EXPERIMENTAL DESCRIPTION.....	4
3.1. Test System.....	4
3.2. Basis of the Method.....	4
3.3. Brief of the Procedure.....	4
3.4. Prediction Model.....	6
4. MATERIALS.....	6
4.1. EpiDerm™ EPI-200.....	6
4.2. Other Materials Needed.....	8
4.3. Preparation of Medical Device Extracts.....	9
5. METHODS.....	9
5.1. MTT Medium (Prepare Fresh on Day of Testing).....	9
5.2. Test Material and Preparation of Control.....	9
5.3. Receipt of the EPI-200 Tissues (Day 0).....	10
5.4. Preparation and Pre-incubation (Day 0).....	10
5.5. Application of the Test Substance and Rinsing (Day 1).....	12
5.5.1. Preparation.....	12
5.5.2. Test extract and controls exposure.....	13
5.6. Basal Media Collection for IL-1 α Analysis.....	14
5.7. MTT Assay.....	14
5.8. Formazan Extraction.....	15
5.9. Absorbance Measurements.....	15
6. VIABILITY EXPRESSION AND ACCEPTABILITY CRITERIA.....	17
6.1. Data Report Forms and Calculations (per time point).....	17
6.2. Data Calculation Steps.....	19
6.3. Assay Acceptance Criteria for Negative and Positive Controls.....	20
7. DATA INTERPRETATION – PREDICTION MODEL.....	20
8. QUALITY ASSURANCE AND ARCHIVING.....	21
9. METHOD DOCUMENTATION SHEET (MDS).....	21
10. TEST METHOD OUTLINE.....	22
11. REFERENCES.....	23
ANNEX 1: METHOD DOCUMENTATION SHEET (MDS).....	24
ANNEX 2: CHARACTERISATION OF TEST SUBSTANCES.....	30
ANNEX 3: ISO 10993-12 EXTRACTION PROCEDURE.....	31

EpiDerm™ SKIN IRRITATION TEST FOR MEDICAL DEVICE EXTRACTS

The irritation potential of a chemical may be predicted by measurement of its cytotoxic effect, as reflected in the MTT assay, using a reconstructed human epidermis (RhE) as a model. This protocol describes the use of the EpiDerm™ (EPI-200) RhE available from MatTek Corporation, USA and MatTek In Vitro Life Science Laboratories (Slovakia).

General

TYPE OF TESTING:

Skin Irritation of Medical Device Extracts using Reconstructed human Epidermis (RhE).

LEVEL OF ASSESSEMENT:

Identification of skin irritation hazard to inform safety assessment.

PURPOSE OF TESTING:

To detect skin irritation of Medical Device Extracts using RhE without the use of laboratory animals (rabbits).

CONTACT PERSONS:

Dr. Silvia Letasiova, MatTek IVLSL, Slovakia (sletasiova@mattek.com)

Mr. Mitchell Klausner, MatTek Corporation, USA (mklausner@mattek.com)

1. RATIONALE AND BACKGROUND

The test is designed to predict and classify the skin irritation potential of medical device extracts by measuring the effect of the extracts on the viability of reconstructed human epidermis (RhE).

The EpiDerm™ Skin Irritation Test (SIT) method for determining skin irritation of chemicals has been validated by the European Centre for the Validation of Alternative Methods (ECVAM) and is included in OECD Technical Guideline 439 and EU Guideline B.46. This method was validated with neat industrial chemicals for the purpose of classification and labeling. This modified EpiDerm™ Skin Irritation Assay protocol is used to determine whether the presence of irritants in medical device extracts (that may be present at very low concentrations) will result in irritation. The negative control is Dulbecco's Phosphate Buffered Saline (DPBS) and/or vehicles used for extraction of the medical device (saline, sesame oil) while the positive control is a 1% solution of Sodium dodecyl sulfate (SDS) in polar and non-polar vehicles. Vehicle controls are saline solution and sesame oil that have undergone the ISO 10993-12 medical device extraction procedure.

2. SPECIFIC PURPOSE OF THE METHOD

The present test is designed to predict and classify the skin irritant potential of extracts from medical devices according to the requirements of ISO standards 10993-1:2009, 10993-5:2009, 10993-10:2010, and 10993-12:2012 using the RhE model EpiDerm™ (EPI-200) and parameters related to skin irritation.

3. BRIEF EXPERIMENTAL DESCRIPTION

3.1. Test System

Epidermis model

The reconstructed human epidermal model, EpiDerm™ (EPI-200, MatTek Corporation, Ashland, MA, USA and MatTek IVLSL, Bratislava, Slovakia), consists of normal human-derived epidermal keratinocytes, which have been cultured to form a 3-dimensional, multilayered, highly differentiated model of the human epidermis. It consists of organized basal, spinous and granular layers, and a multilayer stratum corneum containing intercellular lamellar lipid layers arranged in patterns analogous to those found *in vivo*.

The EpiDerm™ tissues (surface 0.63 cm²) are cultured on specially prepared cell culture inserts and shipped world-wide as kits, containing 24 tissues on shipping agarose together with the necessary amount of culture media, DPBS, 6-well plates, and 24-well plates. The specialized kits are provided by MatTek under the part # EPI-200-SIT-MD.

MatTek also recommends use of its MTT kit (MTT-100, containing MTT concentrate, diluent, and extractant) to avoid variation and mistakes that can happen during the preparation of the MTT solutions. MTT-100 kits must be ordered separately.

Quality Control

EpiDerm™ tissues are manufactured according to defined quality assurance procedures (GMP). All biological components of the epidermis model and the culture medium are tested by manufacturer for viral, bacterial, fungal and mycoplasma contamination. MatTek measures ET-50 following exposure to 1% Triton X-100 for each EpiDerm lot. The ET-50 must fall within a range established based on a historical database of results.

3.2. Basis of the Method

Endpoints: Cell viability determination is based on cellular reduction of MTT, and subsequent conversion to a purple formazan salt that is quantitatively measured after extraction from tissues (Faller et al., 2002; Mosmann, 1983). The cell viability of treated tissues is compared to negative controls and expressed as a percentage. The percent reduction in viability is used to predict the irritation potential. Interleukin-1 alpha (IL-1 α) can be measured in the basal media as a secondary endpoint that may help to increase sensitivity. This is an optional endpoint that is not currently included in the prediction model (Section 3.3). If basal media is collected for IL-1 α analysis, it should be stored frozen at -20°C prior to analysis.

3.3. Brief Procedure

Studies performed with biomaterials manufactured specifically to contain irritant chemicals at low concentrations concluded that 18 hours exposure to extracts from biomaterials is sufficient to predict irritation in vitro. The EpiDerm skin model is used and reduction of tissue viability below 50% as measured by the MTT assay, is the endpoint (Casas et al, 2013; Kandarova et al. 2015).

In this protocol, biomaterials are first extracted with polar and non-polar solvent vehicles. Following extraction, 100 µL of the extracts are topically applied to the EpiDerm™ (EPI-200) tissues and incubated at 37°C / 5% CO₂ for 18 hours. Three tissue replicates are used per test material (extract). Tissues treated with 1% (v/v) solutions of SDS in sesame oil and in saline solution are used as positive controls, and DPBS-treated tissue is used as the negative control. *Note: Vehicle controls should include saline solution and sesame oil that have undergone the ISO 10993-12 medical device extraction procedure.*

Exposure to the test sample extract is terminated by rinsing with DPBS. The viability is assessed immediately after the rinsing step by incubating the tissues for 3 hours with MTT solution in a 24-well plate (1 mg/mL; 0.3 mL per well). The formazan produced by the tissues in response to incubation with MTT is then extracted using 2.0 mL of isopropanol (MTT-100-EXT). Two aliquots per tissue of extracted formazan are added to two wells of a 96-well plate (200 µL/well) and quantified spectrophotometrically at 570 nm. For each treated tissue, the viability is expressed as a percent relative to the mean of the negative DPBS treated control tissues.

Aliquots of culture media can be collected after the 18 hours exposure and stored frozen (-20°C) for cytokine (IL-1α) measurements (optional).

Known limitations of the method: The method is not applicable to gases and aerosols.

Known cases of test-compounds requiring specific controls: Some chemicals can directly reduce the MTT reagent (e.g., electrophiles, test articles with high pH), while other chemicals can directly color the tissue or the cells. Such test substance properties can only interfere if sufficient amounts of the chemical are still present on the tissue at the end of the exposure / rinsing period. In these cases, a special procedure allowing the quantification of the “true” MTT reduction should be applied. The use of specific and adapted controls will enable the calculation of true tissue viability after subtracting the unspecific optical density (OD) due to direct chemical MTT reduction and/or chemical residual color extracted from the tissues. Conditions for use of specific controls are described in EPI-200-SIT protocol (protocol # MK-24-007-0023), available from MatTek Corporation.

3.4. Prediction Model (PM)

This prediction model is based on the prediction model of the OECD TG 439 and data generated during the optimization of the medical device (MD) protocol (Casas et al., 2013; Kandarova et al., 2015) and the subsequent validation study (Kandarova et al., 2018).

If cell viability at 18 hours exposure time is \leq 50%: the chemical is classified as Irritant (I).

If cell viability at 18 hours exposure time $>$ 50%: the chemical is classified as Non-Irritant (NI)

4. MATERIALS

4.1. EpiDerm™ EPI-200

Precautions

The epidermal cells used to produce EPI-200 are isolated from healthy volunteer donors negative to anti-HIV 1 and 2, and to hepatitis C antibodies, and to hepatitis B antigens. Nevertheless, normal handling procedures for biological materials should be followed:

- (a) It is recommended that gloves be worn during handling.
- (b) After use, the epidermal tissue model, the extracts, and all media used in the assay should be decontaminated (for example, by using a 10% solution of bleach or appropriate containers), prior to disposal.

Examine all kit components for integrity. If there is a question or concern, call MatTek Corporation (USA) and/or MatTek In Vitro Life Science Laboratories (EU).

Mitchell Klausner (USA)

Phone: +1-508-881-6771 x214

Email: mklausner@mattek.com

Silvia Letasiova (EU)

Phone: +421-2-3260-7401

Email: sletasiova@mattek.com

Berta Gershenovich (USA)

Phone: +1-508-881-6771 x114

Email: bgershenovich@mattek.com

EPI-200-SIT-MD Kit Components

Qty/Volume	Description	Use/Comments
Agar filled plate containing EPI-200 tissues	24 EpiDerm tissues (tissue surface area: 0.63 cm ²)	Tissues in cell culture inserts, maintained on nutritive agar for transport
2 plates	24-well assay plates	For assays
8 pates	8 x 6-well plates	For assays and pre-incubations
1x 125 mL bottle	Sterile Assay Medium (EPI-100-NMM)	DMEM based culture medium
1 x 125 mL bottle	Sterile DPBS	For negative control and rinsing tissues
1 x cryotube, 1.2 mL	20% SDS	Stock solution used for preparing 1% SDS (positive control)

MTT-100 Assay Kit Components (ready-to-use kit, must be ordered separately)

Qty/Volume	Description (part#)	Use/Comments
1 vial, 2 mL	MTT concentrate (MTT-100-CON)	Frozen MTT concentrate (5 mg/mL)
1 vial, 8 mL	MTT diluent (MTT-100-DIL)	For diluting MTT concentrate prior to use in the MTT assay
1 bottle, 60 mL	Extractant Solution (MTT-100-EXT)	For extraction of formazan

Expiration and Kit Storage

Part #	Description	Conditions	Shelf life*
EPI-200-SIT-MD	EpiDerm cultures	refrigerator (2-8°C)	96 hours
EPI-100-NMM	Assay medium	refrigerator (2-8°C)	2 Weeks
MTT-100-DIL	MTT diluent	refrigerator (2-8°C)	2 months
MTT-100-CON	MTT concentrate	freezer (-20±5°C)	2 months

*Refers to storage time @ 2-8°C in unopened package.

4.2. Other Materials Needed

Materials needed	Description of use within the assay
Microbiological safety cabinet (laminar flow hood)	For safe work under sterile conditions
Non-sterile ventilated cabinet	For safe work with chemicals, applications, washes
Cell incubator 37±1°C, 5%±1% CO ₂ , 90±10% humidity	For incubating tissues
Plate reader (96-well) with a 570 nm filter	For OD readings (MTT)
Water bath at 37±1°C	For warming media
Vacuum source/trap and Pasteur pipettes	For aspirating media and solutions
Laboratory balance (accuracy 0.1 mg)	For checking chemicals weight and spatula weight
Orbital shaker	For shaking before media sampling, and agitation of sample extractions during incubation
Wash bottle (500 mL)*	For rinsing tissues
Sterile DPBS and/or PBS (without Ca ²⁺ and Mg ²⁺)	For rinsing tissues, ~two liters is sufficient for use as the negative control (DPBS) and for all rinsing performed with one kit
Flasks and 200 mL beakers	For rinsing tissues and submerging rinsed tissues
Adjustable micro-pipette – 0 to 200µL	For pipetting 200 µL formazan extracts following MTT extraction
Adjustable micro-pipette – 0 to 1000µL	For pipetting assay and maintenance media
Adjustable positive displacement micro-pipette - 0 to 100 µL	For application of test samples and controls
Stop-watches/Timers	For controlling contact and step times
Bulb headed glass Pasteur Pipettes	For spreading samples on tissue, piercing tissue after MTT extraction
Small sterile blunt-edged forceps	For handling tissue inserts
Sesame oil Sigma-Aldrich 85067 (was Fluka 85067) or Spectrum Chemicals, Sesame Oil, NF, Nr: SE130, CAS Number: 8008-74-0.	Pharmaceutical grade to be used as nonpolar vehicle
Saline (0.9 % solution of NaCl)	to be used as polar vehicle
96-well plates	For reading OD of extracted MTT
Adhesive tape or Parafilm M	For covering plates during MTT extraction to minimize evaporation
Sterile cotton swabs	For drying the tissue surfaces
Sterile Water	For preparation of 1% SDS
Incubator capable of 37±1°C	For sample extractions

4.3. Preparation of Medical Device Extracts

Document the information on the test substances/medical devices in the table of **Annex 2: Characterisation of test substances**. Polymer material extracts are prepared according to ISO 10993-12 guidelines and are based on surface area/weight to volume ratios described in this standard.

- Polar extracts are prepared in 0.9 % saline solution (0.9 g NaCl in 100 mL ultrapure or deionized water).
- Non-polar extracts are prepared in pharmaceutical grade sesame oil.

Note: The extraction should be performed at $37 \pm 1^\circ\text{C}$ for 72 ± 2 hours with continuous agitation/shaking.

5. METHODS

A short description of the various steps involved in performing the *in vitro* skin irritation test is presented in Section 11. The text below provides a detailed description of all steps and handling in the assay.

5.1. MTT Medium (Prepare Fresh on Day of Testing)

If using the ready-to-use MTT kit from MatTek (part # MTT-100), thaw the MTT concentrate (MTT-100-CON) and dilute with the MTT diluent (MTT-100-DIL). Store the remaining MTT solution in the dark for later use on the same day (do not store overnight since MTT will degrade with time).

If not using the MTT-100 kit, prepare a stock solution (5 mg/mL) of MTT in DPBS. The stock solution can be stored frozen ($-20 \pm 5^\circ\text{C}$) for up to 2 months. Before use, filter the stock solution and dilute the filtrate with the assay medium to final concentration (1 mg/mL). Record the preparation in the MDS. Do not store the diluted MTT solution overnight.

Safety precautions: MTT is toxic (Risk phrases: H315, H319, H335, H341). Wear protective gloves during handling of MTT.

Note: MTT is light sensitive. Protect all solutions from light.

5.2. Test Materials and Preparation of Controls

Record the main information about the test chemicals and control chemicals, including codes or numbers, physical consistence, volumes or weight, expiration date and storage conditions in **Annex 1 and 2**.

Preparation of the Negative Control (DPBS):

The negative control (NC) is Dulbecco's Phosphate Buffered Saline (DPBS). Sterile ready-to-use DPBS is supplied with the EPI-20-SIT-MD kit.

Preparation of the Vehicle Controls (VCs)

The vehicle controls (VCs) (0.9% saline and sesame oil) should be placed into the (amber glass vial) extraction vessels and subjected to the identical extraction procedure (72 hours at 37°C) as the test materials. Details of this ISO 10993-12 extraction procedure are provided in **Annex 3**.

Preparation of the Positive Controls (PC: 1% v/v SDS):

1% (v/v) working solution of SDS should be prepared in each of the vehicles used in the assay. Add 500 µL of 20% SDS stock (provided with the EPI-200-SIT-MD kit) to 9.5 mL of each vehicle and thoroughly vortex. From these preparations, a volume of 100 µL will be removed using a positive displacement pipette and applied to the tissues.

For the 1% SDS in sesame seed oil, which forms an emulsion after preparation from the stock solution, if needed, spread the PC solution with the bulb headed glass Pasteur pipette to ensure contact with the entire epidermis.

Note: The PC in both vehicles must be prepared fresh on the day of the experiment.

5.3. Receipt of the EPI-200 Tissues (Day 0)

Enter the EPI-200-SIT-MD kit and assay details on the Methods Documentation Sheet (MDS).

- (a) Place the EpiDerm tissues and the EPI-100-NMM medium in a refrigerator (2-8°C) until they are used. DPBS and 20% SDS are stored at room temperature.
- (b) If the MTT-100 kit has been ordered, place the MTT concentrate at -20±5°C, MTT-100-DIL at 2-8°C (refrigerator) and the extractant (MTT-100-EXT) at room temperature.

5.4. Preparation and Pre-incubation (Day 0)

- (a) Pipette 0.9 mL of the assay medium into each well of sterile 6-well plates (for 24 inserts, prepare eight 6-well plates). Use one 6-well plate for pre-incubation of three inserts. Allow the EPI-100-NMM medium to reach room temperature (20-25°C).
- (b) Under sterile conditions, open the plastic bag containing the 24-well plate with epidermal tissues. Under a sterile airflow, remove the sterile gauze and carefully (using sterile forceps) take out each insert containing the epidermal tissue. Remove any remaining agarose that adheres to the outer sides of the insert by gentle blotting on the sterile filter paper or gauze, and place the tissues in the empty, sterile 24-well plate (Figure 1).

Note: *The 24-well plate used for shipping may be kept/stored sealed at RT to look for signs of possible contamination at the end of the week.*

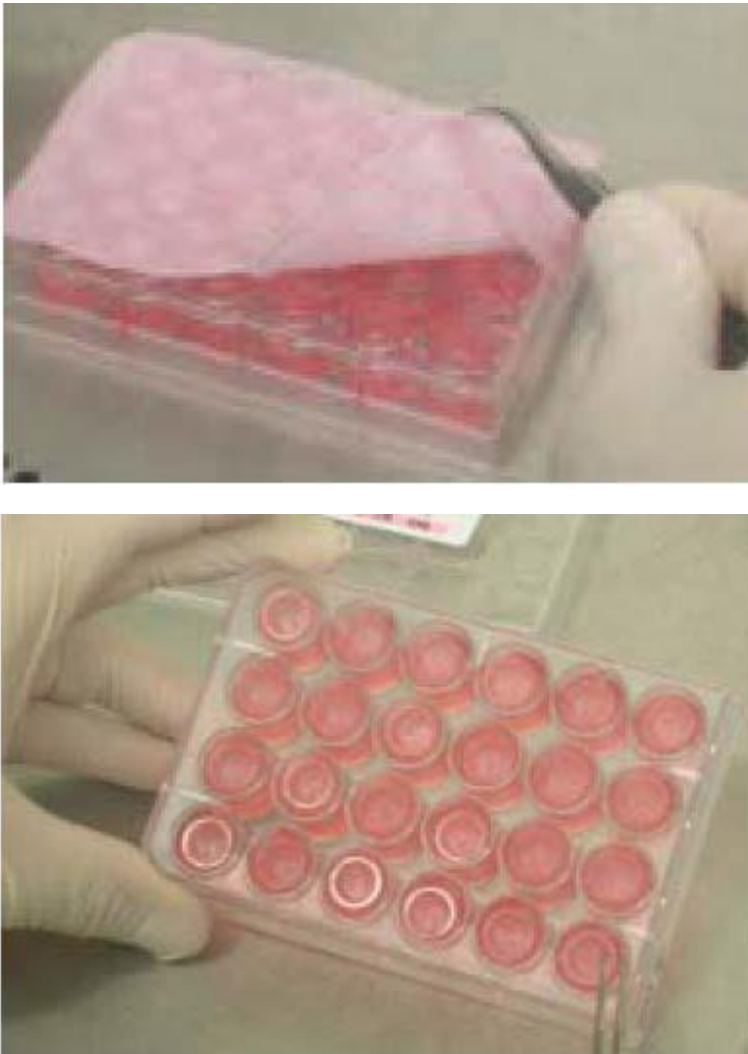


Figure 1. Visual inspection of the epidermal tissues.

- (c) Perform visual inspection of the inserts within the next 5 minutes. Record any tissue defects and excess moisture on the surface. Do not use tissues with defects or tissues with excessive moisture on the surface.
- (d) Dry the surface of the tissues with a sterile cotton tip swab and transfer inserts with the tissues to a 6-well plate pre-filled with 0.9 mL medium. Place the plates for 60 ± 5 minutes into the incubator ($37 \pm 1^\circ\text{C}$, $5 \pm 1\%$ CO_2 , $90 \pm 10\%$ RH).
- (e) At the end of the first pre-incubation period, transfer the inserts from upper wells into the lower wells of the 6-well plate (Figure 2). Incubate the tissues ($37 \pm 1^\circ\text{C}$, $5 \pm 1\%$ CO_2 , $90 \pm 10\%$ RH) overnight for approximately 18-24 hour.

Note: Alternatively, six tissues can be pre-incubated in one 6-well plate and the medium carefully replaced after the 60 minutes pre-incubation period.



Figure 2. Pre-incubation plate design.

5.5. Application of the Test Extract and Rinsing (Day 1)

Safety precautions: Irritant materials are dangerous. It is thus recommended to work in ventilated cabinets and wear protective gloves, a mask and safety glasses, as necessary.

5.5.1. Preparation

- (a) Remove the 6-well plates containing EPI-200 tissues from the incubator approximately 5 minutes before exposure to the extracts.
- (c) Evaluate the surface of tissues and exclude completely wet tissues or tissues with visible defects.
- (d) Remove any moisture from the tissue surface using sterile cotton swab.
- (e) Before exposing the tissues to the extracts:
 - * label all 6-well plate lids with the test material codes.
 - * Replace the medium below the inserts (add 0.9 mL medium) or transfer inserts to a new 6-well plate with fresh medium (0.9 mL)

5.5.2 Test extract and controls exposure

- (a) Apply 100 μ L of each undiluted medical device extract, the NC, the VCs and the PC in saline and sesame oil to N=3 tissues. Dose the tissues at the time intervals needed later for rising off the test extracts (optimal and highly recommended are 1 minute intervals).
- (b) Keep the plates with the dosed tissues in the laminar flow hood until the last tissue is dosed.
- (c) After dosing the last tissue, transfer all plates to the humidified incubator ($37\pm 1^{\circ}\text{C}$, $5\pm 1\%$ CO_2 , $90\pm 10\%$ RH) for the necessary exposure time (18 hours \pm 30 minutes).
- (d) When the exposure is complete, rinse the tissues with sterile DPBS by filling and emptying each tissue insert 15 times to remove any residual test material (Figure 3). Use a constant stream of DPBS applied from 1.5 cm distance from the tissue surface. The stream of DPBS should not be too gentle otherwise the test article will not be removed. An optimal wash bottle, with pointed endings, is shown in Figure 3.
- (e) After the 15th rinse from washing bottle, completely submerge the insert 3 times in 150 mL DPBS (shake to remove any residual DPBS).



Figure 3. Removal of test articles and controls – washing procedure.

- (f) Finally, rinse the tissue once from inside and once from outside with sterile DPBS. Remove excess of DPBS by gently shaking the insert, blot the insert by placing on adsorbent paper (Figure 4, left).
- (g) Transfer each tissue insert to a 24-well plate pre-filled with fresh assay medium (0.3 mL/well) until all tissues have been rinsed.
- (h) Carefully dry the surface of each tissue with a cotton tipped swab (Figure 4). If traces of the extract are still present on the surface, try to remove them with a sterile cotton swab wetted with DPBS. You may visually evaluate the tissue surface under a dissecting stereoscope. Record this procedure in the MDS.



Figure 4. Completion of tissue washing – blotting and drying the tissue surface

5.6 Basal Media Collection for IL-1 α Analysis – optional

- (a) If IL-1 α will be analyzed, seal the 6-well plates of culture media in which the tissues were exposed to the test materials with Parafilm and store them at $-20 \pm 5^{\circ}\text{C}$ until analysis. Frozen media samples can be stored for 12 months.

5.7 MTT Assay

Note: The MTT assay is performed immediately after the 18 hour exposures are finished. There is no post-exposure time as in the EpiDerm SIT (OECD TG 439).

Note: The preparation of the MTT-solution and pre-filling of 24-well plate (0.3 mL/well) should be performed before starting the washing procedure.

- (a) Prior to the MTT assay, label a sufficient number of 24-well plates.
- (b) Prepare the MTT solution (Section 5.2) and pipette 300 μL of MTT solution (1 mg/mL) into each well of the required number of 24-well plates.
- (c) Remove the inserts from the temporary storage plates, dry the bottom of each insert by pressing it against sterile adsorbent paper, and transfer them into the 24-well plates, pre-filled with 0.3 mL of MTT (1 mg/mL). Place the plates in the incubator ($37 \pm 1^{\circ}\text{C}$, $5 \pm 1\%$ CO_2 , $90 \pm 10\%$ RH), record the start time of MTT incubation in the MDS and incubate for 3 hours \pm 5 minutes.

Note: The 3 hours \pm 5 minutes MTT incubation time must be strictly adhered to. Deviations from the 3 hour time for MTT incubation will result in different MTT readings.

5.8 Formazan Extraction

- (a) After the MTT incubation is complete, blot any residual MTT solution from the tissue inserts and transfer the tissues to 24-well plates prefilled with 2.0 mL of isopropanol (extractant solution, MTT-100-EXT) per well. Submerge the tissues fully.
- (b) Seal the 24-well plates (e.g., with Parafilm or place into a sealable plastic bag) to inhibit extractant evaporation. Record start time of extraction in the MDS and

extract the formazan for at least 2 hours at room temperature with **gentle** shaking on a plate shaker (~ 120 rpm).

- (c) As an alternative, overnight extraction (18-24 hours) can be used. Seal plates as described above and extract in the dark at room temperature or in the refrigerator, without shaking. Before quantifying the extracts, let them warm to RT.
- (d) After the extraction period is complete, pierce the membranes of the inserts with a bulb headed Pasteur pipette and allow the extract to run into the well from which the insert was taken. Once drained, the insert with the tissue can be discarded. Before transferring the extract from the wells of the 24-well plate into 96-well plates, pipette up and down at least 3x until the extractant solution is homogenous.

5.9 Absorbance Measurements

- (a) For each tissue, transfer 2 x 200 μ L samples/well into a 96-well flat bottom microtiter plate (labeled appropriately) according to the fixed plate design given in spreadsheet (example is given in Figure 5). Use isopropanol (MTT-100-EXT) as blanks.

Note: Be careful to avoid isopropanol evaporation in the 96-well plates. Include VC1 and VC2 as per the plate maps below. VC1 and VC2 are always 0.9% saline and sesame oil vehicle controls, respectively.

Plate 1

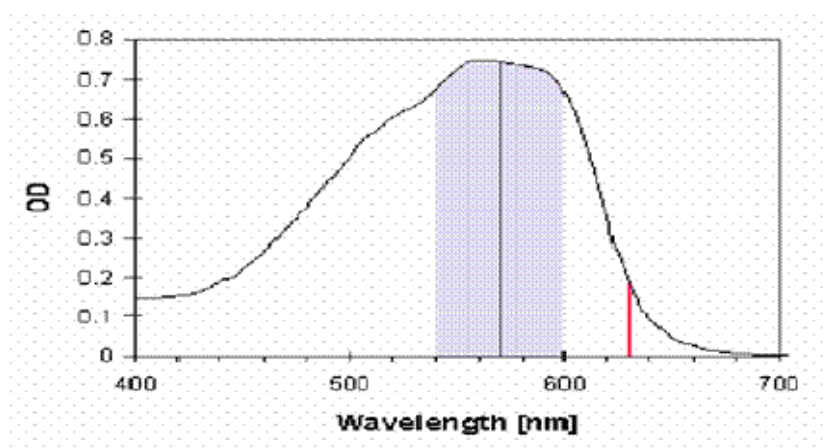
	1	2	3	4	5	6	7	8	9	10	11	12	
	BL	BL	BL	BL	BL	BL							A
Tissue 1	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	B
	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	C
Tissue 2	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	D
	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	E
Tissue 3	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	F
	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	G
													H

- BL Blank, Isopropanol
- NC Negative Control, DPBS.
- PC1 Positive Control 1, 1% SDS in saline.
- PC2 Positive Control 2, 1% SDS in in sesame oil.
- VC1 Vehicle Control 1, Saline.
- VC2 Vehicle Control 2, Sesame oil.
- TA1-TA7 Test sample 1-7 in saline and/or sesame oil.

Figure 5. Fixed 96 well-plate design (for OD reading in 96-well plate reader, 2 aliquots per tissue)

- (b) Read the optical density (OD) in a 96-well plate spectrophotometer using wavelength filter centered at **570 nm** pass-band $\pm 30\text{nm}$ and isopropanol solution as blank **without using a reference filter**.

Note: Readings are performed without a reference filter, since the "classical" reference filter often used in the MTT test (**630 nm**) is still within the absorption curve of formazan. Since filters have a tolerance their use can lead to a reduction of the dynamics of the signal (OD).



- (c) Record results on **prepared templates**. Templates can be linked to specific readers program. A direct print of the readings should be made immediately and identified with date and signature and kept as raw data.

6 VIABILITY EXPRESSION AND ACCEPTABILITY CRITERIA

6.1 Data Report Forms and Calculations (per time point)

General Information:						Negative control						NC
Study no.:						Positive control 1						PC1
Tissue-lot no.:						Positive control 2						PC2
Date:						Vehicle control 1						VC1
Operator:						Vehicle control 2						VC2
						Test Article No. 1						TA1
						Test Article No. 2						TA2
						Test Article No. 3						TA3
						Test Article No. 4						TA4
						Test Article No. 5						TA5
						Test Article No. 6						TA6
						Test Article No. 7						TA7

FIXED DESIGN OF 96 WELL PLATE

PLATE 1

	1	2	3	4	5	6	7	8	9	10	11	12	
A	BLANK	BLANK	BLANK	BLANK	BLANK	BLANK	empty	empty	empty	empty	empty	empty	
B	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	Tissue1
C	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	
D	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	Tissue2
E	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	
F	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	Tissue3
G	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	
H	empty	empty	empty	empty	empty	empty	empty	empty	empty	empty	empty	empty	

IMPORT:

PLATE 1

	1	2	3	4	5	6	7	8	9	10	11	12	
A	0.047	0.046	0.044	0.045	0.045	0.046	0.033	0.035	0.033	0.035	0.034	0.036	
B	2.136	0.132	0.150	2.062	2.000	2.001	2.114	1.915	2.280	1.224	0.789	1.896	Tissue1
C	2.195	0.134	0.147	2.108	2.000	2.088	2.152	1.976	2.191	1.219	0.788	1.755	
D	2.210	0.133	0.151	2.130	1.959	2.059	2.147	1.971	2.214	1.225	0.769	1.763	Tissue2
E	2.210	0.141	0.146	2.105	2.100	2.163	2.023	2.063	2.080	1.198	0.746	1.756	
F	2.163	0.139	0.152	2.018	2.103	2.180	2.144	2.063	2.182	1.156	0.756	1.659	Tissue3
G	2.136	0.135	0.144	1.990	2.121	2.203	2.133	2.067	2.178	1.166	0.778	1.689	
H	0.035	0.033	0.035	0.034	0.036	0.037	0.037	0.033	0.035	0.034	0.033	0.034	

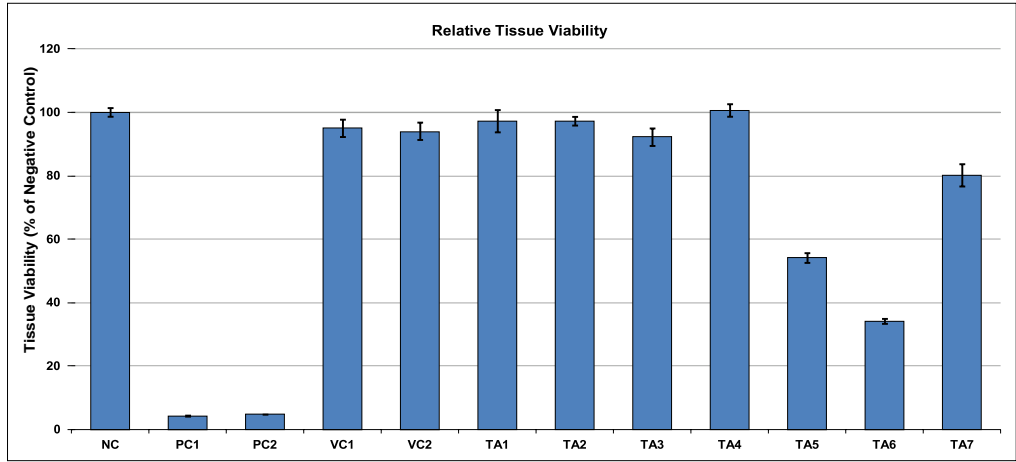
REMARKS

In Vitro Skin Irritation Test for Medical Device Extracts

RESULTS

exp. no.:	0
tissue-lot no	0
date:	0
operator:	0

Blank	0.047
	0.046
	0.044
	0.045
	0.045
Mean	0.0455



Code N°	Tissue n	Raw data		Blank corrected data		mean of aliquots	% viability
		Aliq. 1	Aliq. 2	Aliq. 1	Aliq. 2		
NC	1	2.136	2.195	2.091	2.150	2.120	99.6
	2	2.21	2.21	2.165	2.165	2.165	101.6
	3	2.163	2.136	2.118	2.091	2.104	98.8
PC1	1	0.132	0.134	0.087	0.089	0.088	4.1
	2	0.133	0.141	0.088	0.096	0.092	4.3
	3	0.139	0.135	0.094	0.090	0.092	4.3
PC2	1	0.15	0.147	0.105	0.102	0.103	4.8
	2	0.151	0.146	0.106	0.101	0.103	4.8
	3	0.152	0.144	0.107	0.099	0.103	4.8
VC1	1	2.062	2.108	2.017	2.063	2.040	95.8
	2	2.13	2.105	2.085	2.060	2.072	97.3
	3	2.018	1.99	1.973	1.945	1.959	92.0
VC2	1	2	2	1.955	1.955	1.955	91.8
	2	1.959	2.1	1.914	2.055	1.984	93.2
	3	2.103	2.121	2.058	2.076	2.067	97.0
TA1	1	2.001	2.088	1.956	2.043	1.999	93.9
	2	2.059	2.163	2.014	2.118	2.066	97.0
	3	2.18	2.203	2.135	2.158	2.146	100.8
TA2	1	2.114	2.152	2.069	2.107	2.088	98.0
	2	2.147	2.023	2.102	1.978	2.040	95.8
	3	2.144	2.133	2.099	2.088	2.093	98.3
TA3	1	1.915	1.976	1.870	1.931	1.900	89.2
	2	1.971	2.063	1.926	2.018	1.972	92.6
	3	2.063	2.067	2.018	2.022	2.020	94.8
TA4	1	2.28	2.191	2.235	2.146	2.190	102.8
	2	2.214	2.08	2.169	2.035	2.102	98.7
	3	2.182	2.178	2.137	2.133	2.135	100.2
TA5	1	1.224	1.219	1.179	1.174	1.176	55.2
	2	1.225	1.198	1.180	1.153	1.166	54.8
	3	1.156	1.166	1.111	1.121	1.116	52.4
TA6	1	0.789	0.788	0.744	0.743	0.743	34.9
	2	0.769	0.746	0.724	0.701	0.712	33.4
	3	0.756	0.778	0.711	0.733	0.722	33.9
TA7	1	1.896	1.755	1.851	1.710	1.780	83.6
	2	1.763	1.756	1.718	1.711	1.714	80.5
	3	1.659	1.689	1.614	1.644	1.629	76.5

	mean of OD	SD of OD	mean of viabilities [%]	SD of viabilities	CV %
NC	2.130	0.031	100.0	1.47	1.47
PC1	0.090	0.002	4.2	0.11	2.56
PC2	0.103	0.000	4.8	0.01	0.28
VC1	2.023	0.058	95.0	2.74	2.89
VC2	2.002	0.058	94.0	2.73	2.90
TA1	2.070	0.074	97.2	3.46	3.56
TA2	2.073	0.029	97.4	1.38	1.42
TA3	1.964	0.060	92.2	2.82	3.06
TA4	2.142	0.045	100.6	2.10	2.09
TA5	1.153	0.032	54.1	1.52	2.81
TA6	0.726	0.016	34.1	0.75	2.19
TA7	1.708	0.076	80.2	3.57	4.45

Classification

Code	Classification	Result
NC	NI	Qualified
PC1	I	Qualified
PC2	I	Qualified
VC1	NI	Qualified
VC2	NI	Qualified
TA1	NI	Qualified
TA2	NI	Qualified
TA3	NI	Qualified
TA4	NI	Qualified
TA5	NI	Qualified
TA6	I	Qualified
TA7	NI	Qualified

All data/calculations should be recorded on prepared **Data Report Forms**. Excel prepared spreadsheets provided by MatTek should be used.

All data generated by the microplate reader should be printed after each reading and considered as raw data, dated and signed.

Blank data and compound data (OD) are copied and pasted in the prepared Excel tables named: "IMPORT sheet" (see example above).

6.2. Data Calculation Steps

These calculation steps are applicable to the majority of test-substances characterized as follows: no interaction with the MTT reagent, non-colored, with a low ability to stain the tissues and measured non-specific color value $\leq 5\%$ relative to negative control.

Main steps automatically followed by the prepared form:

- (a) Blank: calculate the mean OD from the 6 replicates for each plate.
- (b) Negative control (DPBS): Subtract mean OD of the blank from the OD of each individual NC tissue. The mean corrected OD for the 3 NC tissues corresponds to 100% viability.
- (c) Positive control (SDS 1%): Subtract mean OD of the blank from the OD of each individual PC tissue.
- (d) Vehicle controls (VC1: saline; VC2: Sesame oil): Subtract mean OD of the blank from the OD of each individual VC tissue.
- (e) Test extracts : Subtract mean OD of the blank from the OD of each individual tissue.
- (f) The percent viability for each treated tissue (including PC, VC, and test extracts), is calculated relative to the mean of negative controls (see formula below).
- (g) Standard deviations are calculated for OD values and calculated percent viability for each group.
- (h) (g) CV is calculated for percent viability for each group.
- (i) Percent viability calculation:

- 1) The mean OD of the three Negative Controls (DPBS treated) corresponds to 100% reference viability.
- 2) For each individual treated tissue (TT) with a test substance, the positive control (PC) and the vehicle control (VC) the relative viabilities are calculated as follows:

OD Treated tissue = $OD_{TT} - OD_{\text{blank mean}}$
OD Negative Control (ODNC) = $OD_{NC} - OD_{\text{blank mean}}$
OD Positive Control (ODPC) = $OD_{PC} - OD_{\text{blank mean}}$

Individual viabilities (%)

%Positive Control1 = $[OD_{PC1} / \text{mean ODNC}] \times 100$

%Positive Control2 = $[OD_{PC2} / \text{mean ODNC}] \times 100$

%Positive Control3 = $[OD_{PC3} / \text{mean ODNC}] \times 100$

%Treated tissue1 = $[OD_{TT1} / \text{mean ODNC}] \times 100$

%Treated tissue2 = $[OD_{TT2} / \text{mean ODNC}] \times 100$

%Treated tissue3 = $[OD_{TT3} / \text{mean ODNC}] \times 100$

Mean viabilities (%)

Mean Positive Control % = $(\%PC1 + \%PC2 + \%PC3) / 3$

Mean treated tissue % = $(\%TT1 + \%TT2 + \%TT3) / 3$

- 3) The mean relative viability is used for classification according to the prediction model (section 8).

6.3 Assay Acceptance Criteria for Negative and Positive Controls

Negative control (NC) acceptance criteria: OD of the negative control (DPBS treated tissues) reflects the viability of the tissues used in the test conditions (after shipping, storing in specific conditions). An absolute OD below the historical established lower boundary of the confidence interval indicates abnormal viability of tissues thus indicating possible difference in sensitivity to chemicals. These tissues should not be used for this application.

The NC meets the acceptance if the mean OD value of the 3 tissues is ≥ 0.8 and ≤ 2.8 and the Standard Deviation value (SD) of the viability is $\leq 20\%$.

Positive control (PC) acceptance: OD of the positive control (1% SDS-treated tissues) reflects the sensitivity of the tissues used in the test conditions (after shipping, storing in specific conditions). One positive control in either vehicle should be included in each run (maximum one PC per day) taking into consideration the extraction medium (saline or sesame oil) used.

The Positive Control meets the acceptance if the mean viability expressed as percent of the NC, is $\leq 50\%$.

Batch acceptance: All extraction data from one batch are accepted if both the negative and the positive control fulfill the above requirements.

7 DATA INTERPRETATION – PREDICTION MODEL

Irritant potential of the test material extracts is predicted by the mean percent viability of tissues exposed to the test extracts. An irritant is predicted if the mean relative viability is below 50% of the negative control.

Criteria for <i>in vitro</i> interpretation	Classification
Mean tissue viability is $\leq 50\%$ at 18 hr exposure time	Irritant (I)
Mean tissue viability is $> 50\%$ at 18 hr exposure time	Non-Irritant (NI)

8 QUALITY ASSURANCE AND ARCHIVING

The study should be conducted under good laboratory practice (GLP) or other quality control system (e.g., ISO). All modifications of the study protocol must be noted as amendments by the study director. The reasons and practical impact of each modification should be mentioned.

Archiving: Computer raw data and all MDS and any modifications or comments are reported and kept in laboratory registers with identification and signatures. Samples used for the study are stocked in the lab in ventilated conditions until the end of the whole study. Equipment calibration and maintenance data (identified and signed) are maintained and stored as specified in the internal procedures for each laboratory.

9 METHOD DOCUMENTATION SHEET (MDS)

MDS allows compliant Quality Control: correct set up, calibration, function of the equipment and quality of preparations. For each EPI-200 tissue batch and experiment, make hardcopies of the necessary MDS, fill along the experiments the requested information date and sign in the tables of **Annex 1**.

Document the information on the test substances/medical devices in the table of **Annex 2**: Characterization of test substances.

10 TEST METHOD OUTLINE

Skin Irritation Test for Medical Device Extracts

- ❖ Prepare unknown device extracts in a polar (saline) and non-polar (sesame oil) solvent starting 48 hours prior to tissue arrival. Extraction is performed at $37\pm 1^{\circ}\text{C}$ for a total of 72 ± 2 hours with continuous agitation.
- ❖ Upon receipt, transfer the EpiDerm (EPI-200) tissues from the transport plates to 6-well plates containing 0.9 mL of maintenance medium (EPI-100-NMM).
- ❖ Incubate the tissues for 60 ± 5 minutes at $37\pm 1^{\circ}\text{C}$, $5\pm 1\%$ CO_2 , $90\pm 10\%$ RH (in humidified incubator) and then replace the medium with 0.9 mL of fresh EPI-100-NMM.
- ❖ Incubate the tissues for 18 - 24 hours at $37\pm 1^{\circ}\text{C}$, $5\pm 1\%$ CO_2 , $90\pm 10\%$ RH (in humidified incubator).
- ❖ On the day of the dosing, prepare the positive control (SDS) in the polar (saline) and non-polar (sesame oil) vehicles at specified final concentration of 1% (v/v).
- ❖ Apply 100 μL of the negative control (DPBS), a positive control (1% SDS prepared in saline or sesame oil), the vehicle controls (saline and sesame oil), and the extracts from the test materials onto the tissue surface.
- ❖ Incubate the dosed tissues at $37\pm 1^{\circ}\text{C}$, $5\pm 1\%$ CO_2 , in a humidified incubator for 18 hours \pm 30 min.
- ❖ Stop the exposure to the extracts by rinsing the tissues with DPBS.
- ❖ Blot the tissues and transfer them to 24-well plates prefilled with 0.3 mL of EPI-100-NMM until all tissues have been rinsed.
- ❖ After the rinsing of all tissues is finished, transfer the tissues to 0.3 mL of MTT solution in 24-well plates.
- ❖ Freeze the medium from the 6-well plates if IL-1 α will be measured (optional).
- ❖ Incubate the tissues for 3 hours \pm 5 min in MTT solution at $37\pm 1^{\circ}\text{C}$, $5\pm 1\%$ CO_2 , $90\pm 10\%$ RH (in humidified incubator).
- ❖ Transfer the tissues to a new 24-well plate and submerge them in 2.0 mL of extractant (MTT-100-EXT; isopropanol).
- ❖ Extract the formazan produced by the tissues during incubation with MTT at room temperature for 2 hours (with agitation) or overnight without agitation at room temperature. Cover the plate with aluminum foil or place it in a drawer to protect it from light. Seal the plate to prevent evaporation of the extracts.
- ❖ Homogenize the extracted formazan by pipetting up and down (3X) then transfer 200 μL of the extracted solution from each tissue into duplicate wells of a 96-well plate.
- ❖ Determine the OD of the extracts using a plate spectrophotometer at 570 nm.

11 REFERENCES

Casas JW, Lewerenz GM, Rankin EA, Willoughby JA Sr., Blakeman LC, McKim JM Jr, Coleman KP (2013). In Vitro Human Skin Irritation Test for Evaluation of Medical Device Extracts. *Toxicology In Vitro* **27**, 2175-2183.

Draize JH, Woodard G, Calvery HO (1944). Methods for the study of irritation and toxicity of substances applied topically to the skin and mucous membranes. *Journal of Pharmacology and Experimental Therapeutics*. **82**, pp 337-390.

ISO (2009) ISO/TC 194 10993-1 - Biological evaluation of medical devices -- Part 1: Evaluation and testing within a risk management process. International Organization for Standardization, Geneva, Switzerland.

ISO (2009) ISO/TC 194 10993-5 - Biological evaluation of medical devices -- Part 5: Tests for in vitro cytotoxicity. International Organization for Standardization, Geneva, Switzerland.

ISO (2010) ISO/TC 194 10993-10 - Biological evaluation of medical devices -- Part 10: Tests for irritation and skin sensitization. International Organization for Standardization, Geneva, Switzerland.

ISO (2012) ISO/TC 194 10993-12 - Biological evaluation of medical devices -- Part 12: Sample preparation and reference materials. International Organization for Standardization, Geneva, Switzerland.

ISO (2021) 10993-23 - Biological evaluation of medical devices -- Part 23: Test for irritation. International Organization for Standardization, Geneva, Switzerland.

Kandarova H, Hayden P, Klausner M, Kubilus J, Kearney P, Sheasgreen J (2009): In Vitro Skin Irritation Test: Improving the Sensitivity of the EpiDerm Skin Irritation Test Protocol. *ATLA* **37** (6), pp. 671 – 669.

Kandarova H, Willoughby, JA, de Jong, WH, Bachelor, M, Letasiova, S, Milasova, T, Breyfogle, B, de la Fonteyne, L, Coleman, KP (2015). Development, Optimization, and Standardization of an *In Vitro* Skin Irritation Test for Medical Devices Using the Reconstructed Human Tissue Model EpiDerm. *The Toxicologist, Supplement to Toxicological Sciences* **144**, Abstract 2017, 2015.

Kandarova H, Willoughby JA, De Jong WH, Letasiova S, Milasova T, Bachelor MA, Breyfogle B, Handa Y, De la Fonteyne L, Coleman KP (2018). Pre-validation of an in vitro skin irritation test for medical devices using the reconstructed human tissue model EpiDerm. *Toxicol In Vitro*, **50**, 407-417.

MatTek Corporation (2012). Protocol for In Vitro EpiDerm™ Skin Irritation Test (EPI-200- SIT): For use with MatTek Corporation's Reconstructed Human Epidermal Model EpiDerm (EPI- 200-SIT). MK-24-007-0023.

Mosmann T. (1983). Rapid colorimetric assay for cellular growth and survival: application to proliferation and cytotoxicity assays. *J. Immunological Methods* **65**, 55-62.

OECD (2015): OECD guideline for the testing of chemicals No 439: In Vitro Skin Irritation: Reconstructed Human Epidermis Test Method. Organisation for Economic Cooperation and Development, Paris, France.

ANNEX 1: METHOD DOCUMENTATION SHEET (MDS)

Assay Number:

Date:

Corresponding Excel data file name:

PERFORMED BY:..... SIGNATURES:

TIME PROTOCOL

Receipt of EpiDerm tissues (date, day, hour):..... ID:

Experimental schedule

Procedure	Date	Set 1		Set 2	
		start	stop	start	stop
Pre-incubation 1 (60 ± 5 min)					
Pre-incubation 2 (18 – 24 hrs)					
Exposure (18 hrs ± 30 min)					
Washing					
MTT test (3hrs ± 5 min)					
Extraction (minimum 2hrs)					
Measurement					

DEVICE VERIFICATION

Incubator verification

Incubator #	CO ₂ < 5±1% >	Temperature < 37 ± 1°C >	Check water in reservoir (☐)

ID/ Date:

Refrigerator verification

Refrigerator #	Temperature < 5 ± 2°C >

ID/ Date:

Water bath verification

Water bath #	Temperature < 37 ± 1°C >

ID/ Date:

In case that your devices are controlled by central computer, fill in the following table instead of fields above:

Name of the device	device #	reference

ID/ Date:

Pipette verification (triplicate weightings)

Pipette 3 x H₂O into a small baker on a laboratory scale and record readings in g. Perform pipette verification only once per week and refer to it in all assays of this week. If adjustable pipettes are used, check adjustment daily.

	0.9 mL	2 mL	300 µL	200 µL	100µL	remark
1.						
2.						
3.						
Mean						
SD						

ID/ Date:

KIT COMPONENTS

EpiDerm (EPI-200) Lot no.:	Production date:
Assay medium (EPI-100-NMM) Lot no.:	Expiration date:
MTT concentrate (MTT-100-CON); 2 mL Lot no.:	Expiration date:
MTT diluent (MTT-100-DIL); 8 mL Lot no.:	Expiration date:
MTT extractant (MTT-100-EXT), 60 mL Lot no.:	Expiration date:
DPBS (TC-DPBS); 125 mL Lot no:	Expiration date:
Position of Ice-packs: (direct contact of the ice-packs with the skin must be avoided)	
Other remarks	

ID/ Date:

VISUAL QUALITY CONTROL OF THE EpiDerm TISSUES

Use scores: 1- very good, 2-good, 3- acceptable, 4- not acceptable

APPEARANCE	KIT 1	KIT 2
Macroscopic observation		
Number of excluded tissues with: - edge defects - air bubbles - extensive moisture on the surface		

Specific observations:

SOLUTIONS AND VEHICLES

POSITIVE CONTROLS

SDS 1% (v/v) solution in saline and sesame oil, prepared from 20% solution of SDS:

On a day of experiment, prepare fresh solutions of 1% SDS in saline and sesame oil by mixing 100 μ L of 20% SDS with 1.9 mL of vehicle. Vortex thoroughly after preparation and shortly before application to the tissue surface. Expiration is on the same day.

- 20% SDS stock solution reference, Lot #:
- Saline (0.9% NaCl solution), Lot #:
- Sesame oil, Lot #:
- Preparation date:

Saline (0.9 % NaCl) solution preparation:

- NaCl reference, Lot #:
- Type of sterilisation.....
- Preparation date:
- Expiration date :

DPBS solution:

- DPBS concentrate Lot #:
- Expiration date :

Sesame oil:

- Reference, Lot #:
- Expiration date :

REMARKS TO SINGLE TISSUES

If during the assay you observe any abnormality, have to substitute tissues, or encounter any other technical problems, use the following table for recording notes.

Record the tissue number, substance code and your observation or remark.

Substance code	Tissue No.	Remark

ID/ Date:

SPECTROPHOTOMETRIC MEASUREMENT

PLATE CONFIGURATION FOR READING (for transfer to Spreadsheet EpiDerm SIT.xls) :

Record the positions of substances on 96-well plate.
Strictly adhere to the fixed plate design of the SOP given below

	1	2	3	4	5	6	7	8	9	10	11	12	
A	BLANK	BLANK	BLANK	BLANK	BLANK	BLANK							
B	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	Tissue1
C	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	
D	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	Tissue2
E	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	
F	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	Tissue3
G	NC	PC1	PC2	VC1	VC2	TA1	TA2	TA3	TA4	TA5	TA6	TA7	
H													

Note: switch on the reader 10 minutes before reading or as specified in the equipment manual.

Check plate photometer filter

Tick correct () filter setting

reading filter:	
570 (550-570) nm	
no reference filter	

ID/ Date:

ARCHIVATION

Raw data saved in/as:

Spreadsheet saved in/as:

MDS saved in/as:

ANNEX 2: CHARACTERISATION OF TEST SUBSTANCES

Laboratory: Study N°..... Assay N°.....

Test Material Name or Code	Amount of sample used:	Volume of extract added:	Incubator:	Time in:	Time out:	Pre- and post-extraction appearance

ID/ Date:

ANNEX 3: ISO 10993-12 EXTRACTION PROCEDURE

The text of ISO 10993-12:2012 is added for information only.

Preparation of extracts of samples

A3.1 General

If extracts of the device are required for a test procedure, the extraction vehicles and conditions of extraction used shall be appropriate to the nature and use of the final product and to the purpose of the test, e.g. hazard identification, risk estimation or risk assessment. The physicochemical properties of the device materials, leachable substances or residues shall be considered when choosing the extraction conditions.

NOTE: For additional guidance on the extraction of samples, see Annex C (of ISO 10993- 12:2012).

A3.2 Containers for extraction

A3.2.1 The extraction shall be performed in clean, chemically inert, closed containers with minimum dead space.

A3.2.2 To ensure that the extraction vessels do not adulterate the extract of the test sample, the extraction vessels shall be:

- a) borosilicate glass tubes with caps having an inert liner (e.g., polytetrafluoroethylene)
- b) other inert extraction vessels, as required for specific materials and/or extraction procedures.

A3.3 Extraction conditions and methods

A3.3.1 Extraction conditions are based on common practice and are justified on the basis of providing a standardized approach that is, in many ways, an appropriate exaggeration of product use. Extraction shall be conducted under one of the following conditions (see also C.5):

- a) $37 \pm 1^\circ\text{C}$ for 72 ± 2 hr
- b) $50 \pm 2^\circ\text{C}$ for 72 ± 2 hr
- c) $70 \pm 2^\circ\text{C}$ for 24 ± 2 hr
- d) $121 \pm 2^\circ\text{C}$ for $1 \pm 0,1$ hr

NOTE: Extraction at $37 \pm 1^\circ\text{C}$ for 24 ± 2 h in tissue culture media is acceptable for cytotoxicity testing. For medical devices which are in short-term contact with intact skin or mucosa and which are not implanted, extraction times of less than 24 h, but not less than 4 h, are acceptable (see ISO 10993-5). Extraction temperatures greater than $37 \pm 1^\circ\text{C}$ can adversely impact chemistry and/or stability of the serum and other constituents in the culture medium.

The extraction conditions described above, which have been used to provide a measure of the hazard potential for risk estimation of the device or material, are based on historical precedent. Other conditions that simulate the leachables occurring during clinical use, or that provide an adequate measure of the hazard potential, may be used but shall be described and justified.

Extraction is a complex process influenced by time, temperature, surface-area-to-volume ratio, the extraction vehicle and the phase equilibrium¹⁾ of the material. The effects of higher temperatures or other conditions on extraction kinetics and the identity of the extraction vehicle(s) should be considered carefully if accelerated or exaggerated extraction is used.

¹The phase equilibrium of a material during extraction controls the relative amounts of amorphous and crystalline phases present. For the amorphous phase, the glass transition temperature, T_g , dictates the polymer chain mobility and the diffusion rate in the phase.

Usually, at temperatures higher than T_g , the diffusion rate is considerably higher compared with that below T_g . The diffusion rate is lowest in the crystalline phase. The extraction conditions should not alter the phase equilibrium of the material. Phase alteration can affect the amount and type of extractables.

For example, two possibilities exist when elevated temperatures are used:

- the energy of the increased temperature may cause increased cross-linking and/or polymerization of the polymer and, therefore, decrease the amount of free monomer that is available to migrate from the polymer;
- the increased temperature could cause degradation products to form that are not typically found in the finished device under conditions of use.

A3.3.2 For materials that dissolve or resorb under conditions of use, follow the extraction conditions described in 10.3.1. Perform extraction using the appropriate extraction vehicle and time/temperature conditions to simulate exaggerated exposure wherever possible. Complete dissolution may be appropriate.

A3.3.3 The standard surface area can be used to determine the volume of extraction vehicle needed. This area includes the combined area of both sides of the sample and excludes indeterminate surface irregularities. When the surface area cannot be determined due to configuration of the sample, a mass/volume of extracting fluid shall be used. See Table 1.

Other surface-area-to-volume extraction ratios (e.g., those related to evaluation of porous materials, can be used if they simulate the conditions during clinical use or result in a measure of the hazard potential). Materials shall be cut into small pieces before extraction to enhance submersion in the extract media, except when otherwise inappropriate (see 10.3.4). For example, for polymers, pieces approximately 10 mm x 50 mm or 5 mm x 25 mm are appropriate.

Table 1 — Standard surface areas and extract liquid volumes

Thickness mm	Extraction ratio (surface area or mass/volume) ±10 %	Examples of forms of materials
<0,5	6 cm ² /ml	Film, sheet, tubing wall
0,5 to 1,0	3 cm ² /ml	Tubing wall, slab, small moulded items
>1,0	3 cm ² /ml	Larger moulded items
>1,0	1,25 cm ² /ml	Elastomeric closures
Irregularly shaped solid devices	0,2 g/ml	Powder, pellets, foam, non-absorbent moulded items
Irregularly shaped porous devices (low-density materials)	0,1 g/ml	Membranes, textiles

NOTE While there are no standardized methods available at present for testing absorbents and hydrocolloids, a suggested protocol is as follows:
 — determine the volume of extraction vehicle that each 0,1 g or 1,0 cm² of material absorbs;
 — then, in performing the material extraction, add this additional volume to each 0,1 g or 1,0 cm² in an extraction mixture.

A3.3.4 Elastomers, coated materials, composites, laminates, etc. shall be tested intact whenever possible because of potential differences in extraction characteristics between the intact and cut surfaces.

NOTE: As a result of manufacturing processes, many elastomers might have surface properties that are different from those of the bulk material.

A3.3.5 Extraction using both polar and non-polar extraction vehicles shall be performed. The following are examples of extraction vehicles:

- a) polar extraction vehicle: water, physiological saline, culture media without serum;
- b) non-polar extraction vehicle: freshly refined vegetable oil (e.g. cottonseed or sesame oil) of the quality defined in various pharmacopoeias;
- c) additional extraction vehicles: ethanol/water, ethanol/saline, polyethylene glycol 400 (diluted to a physiological osmotic pressure), dimethyl-sulfoxide and culture media with serum.

NOTE 1: Other extraction vehicles appropriate to the nature and use of the device or to the methods for hazard identification may also be used if their effects on the material and the biological system are known (see Annex D).

NOTE 2: The use of a culture medium with serum is preferred for extraction in testing for cytotoxicity because of its ability to support cellular growth as well as extract both polar and non-polar substances.

A3.3.6 Extractions shall be performed with agitation or circulation. When extraction under static conditions is considered to be appropriate, the method shall be justified, specified and reported.

A3.3.7 Liquid extracts shall, if possible, be used immediately after preparation to prevent sorption on to the extraction container or other changes in composition. If an extract is stored for longer than 24 hours, then the stability and homogeneity of the extract under the storage conditions shall be verified.

A3.3.8 Extract pH shall not be adjusted unless a rationale is provided.

A3.3.9 The extract shall not routinely be processed by filtration, centrifugation or other methods to remove suspended particulates. However, if such processing is necessary, the rationale shall be documented.

A3.3.10 For hazard identification of polymeric devices, exhaustive extraction conditions shall be considered. The extraction vehicle and conditions of extraction shall be selected on the basis of physicochemical properties of the material and/or predicted low-molecular-weight chemicals that might be extracted.

A3.3.11 For materials or devices not expected to dissolve or resorb under conditions of use, any solvents used in the extraction of a polymeric material or device shall not cause dissolution of the polymer formulation. No more than a slight softening of the polymeric material shall occur in the presence of the volatile solvent (e.g. less than 10% dissolution). The solvent shall be removed (prior to use in a bioassay) to the extent that any residues do not adversely affect the biological assay (e.g. cause protein denaturation or skin irritation). For materials or devices expected to dissolve or resorb under conditions of use, see 10.3.12.

A3.3.12 For solution and soluble materials, the standard extraction methods used for insoluble materials might be inappropriate. The following guidance should be considered in addition to information contained in Table 1.

a. Factors such as test system compatibility, route of administration and extent of dissolution or degradation should be considered in the final preparation for testing. Use an appropriate vehicle and conditions to simulate exaggerated exposure wherever possible. A pre-test can help to determine appropriate conditions.

b. If the material completely dissolves, in a vehicle or diluent that is compatible with the material and the test system, the resulting solution can be evaluated neat, provided the solution properties are also compatible with the test system, e.g. pH, osmolarity, solute concentrations.

c. If the material is an aqueous solution and used in this form, it shall be tested directly and not extracted, provided the solution properties are compatible with the test system [see also a) and b) above].

d. OECD Guidelines for the Testing of Chemicals, or similar chemical testing standards, can be used as guidance in determining maximum concentrations of test substances used for specific test methods.

A3.3.13 Where fluids circulate through the device under normal conditions of use, e.g. extra- corporeal devices, extraction via re-circulation may be used. When possible, one or more of the conditions shall be exaggerated (e.g., temperature, time, volume, flow rate. The rationale for the extraction chosen shall be reported).

A.4 Extraction conditions for hazard identification and risk estimation in the exaggerated use condition (points to consider in relation to Annex D)

A.4.1 Hazards that arise from changes in the manufacturing process or insufficient control of the manufacturing process shall be considered in the design and

preparation of samples for test and in the preparation of extracts of those devices, in

accordance with ISO 14971. Particular attention shall be given to residues, e.g. trace elements and cleaning and disinfection agents, of those manufacturing processes.

A.4.2 Where the toxic potential is shown to be within the requirement for a product tested by exaggerated and/or exhaustive extraction, there shall be no need to further challenge the device by simulated-use extraction.

A.4.3 In the case of products that polymerize in situ, the samples to be tested shall represent the intended clinical conditions of use in order to provide information on the potential toxicity of the reacting components in the polymer during the curing process. Test extracts prepared at different times, if appropriate, shall be based on the kinetics of polymerization after mixing the components, including an extract prepared at the expected cure time. Testing of the material after curing shall be justified.

Where extracts are used in the test methods for evaluation of materials that cure in situ, initiation of the extraction shall occur from the point in the cure at which the material is placed in situ.

For test methods that use these materials directly (e.g., direct contact or agar overlay cytotoxicity, implantation, some genotoxicity tests, and direct contact haemolysis) the material shall be used as in clinical use, with in situ cure in the test system.

NOTE: Modification of the clinical delivery system might be appropriate so that the designated size or weight of the material is delivered for testing.

Records

Documentation of the sample and its preparation shall include, but not be limited to:

- a) type and, if known, composition of material, source of material, device, device portion or component; NOTE A written description, drawing, photograph or other methods can achieve all or part of this requirement.
- b) lot or batch number, where appropriate;
- c) description of processing, cleaning or sterilization treatments, if appropriate;
- d) extraction techniques, as appropriate, including documentation of extraction vehicle, extraction ratios, conditions for extraction, means of agitation, as well as any deviations from the conditions specified in this part of ISO 10993, such as filtration of the extract or extraction media.