Varying the Immersion Level of a Support Surface in Use

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Abstract

Background: The SS-1 standard [1] describes immersion measurement as a means of comparing different support surfaces, but this measurement has had limited utility during actual clinical use.
Clinician's often require a range of support surface options to provide flexible care [2]. It is beneficial to be able to vary the level of immersion without the need to physically change the surface.

Method: As the patient's needs and condition changes, the clinician can choose to change the mode and pressure levels of the surface. This changes the pressure redistribution and immersion characteristics.

A practical approach involving an integrated bed / support system offering multiple therapy modes was assessed and tested using existing SS-1 test methods involving:

- Simply changing the mode of operation between reactive, pulsation and alternating pressure.
- Varying the surface pressure settings and patient weight setting away from the actual patient weight.

Results: Immersion data for each mode shows significant depths and immersion percentages:
e.g. Reactive 3.47 inches (43%), Low Pulsation 3.94 inches (49%), Alternating Pressure 4.75 inches (62%).
Changing the operating mode of this specific support system changes the immersion level significantly while also providing other beneficial aspects of surface operation.

Conclusion: The immersion level can be adjusted to change the performance of a support surface and the resulting care provided to a patient. Immersion is only one aspect of the provision of pressure injury management, however it is an important parameter in the use of a support surface.

Background

The SS-1 standard [1] describes immersion measurement as a means of comparing different support surfaces, but this measurement has had limited utility during actual clinical use. Each patient has individual needs that can change over time. Clinician's often require a range of support surface options to provide flexible care [2]. It may be beneficial to vary the level of immersion (and hence envelopment) without the need to physically change the surface. There are many clinical benefits of increased immersion and envelopment levels including reduced peak/average interface pressures and reductions in shear effects and tissue deformation.

Support surfaces differ significantly in construction and operation. A foam surface has a fixed immersion level for any particular patient body whereas air-based support surfaces can offer a range of different modes/settings allowing for adjustments during care.

An integrated bed / patient therapy system [C] was analyzed which offered multiple modes of operation (reactive, 3 pulsation levels, alternating) each mode providing differing therapeutic benefits and resulting immersion level, each mode having the ability to further individualize the adjustment of immersion.

Fig 1. Example of an integrated bed / patient therapy system offering a range of therapeutic modes of operation, each with resulting different immersion levels.

Fig 2. Clinician controls to change the mode of operation are located at the foot of the bed.

Methods and Materials

Testing was undertaken using the two different immersion test methods within the ANSI/RESNA SS-1 test standard involving separate independent test laboratories [D,E]. The aim being to quantify the immersive effect when changing the surface operating mode. This adjustment of immersion being proposed as a selectable care option for patients during clinical use, as illustrated in Fig 2.

The method employed was to independently commission separate immersion tests (see Table 1), anatomically focused on the sacral region, a known clinically critical area for pressure injuries. The tests were repeated across a range of modes of operation (from those shown in Fig 3) to measure the level of immersion. The aim was not to compare the results of the two laboratories or differing test methods directly but instead to confirm that each mode had a similar rank in terms of immersion.

SS-1: Section 2 uses a rigid indenter loaded and representing the 50th percentile US male (Fig 4).
SS-1: Section 6 uses a localized instrumented hemispherical indenter (Fig 5).

Further internal company testing was performed to identify the effect of sacral zone pressure adjustments (Fig 6, Fig 7) on the immersion depth of a loaded surface (Fig 9). Although this is outside of the scope of testing as defined in the SS-1 standard, this method can be used to provide further immersion adjustment within a selected operating mode. This is available to the clinician by using the adjustment controls (Fig 6, Fig 7) as described in the operators manual [3].

For comparison purposes, a reactive foam-based surface [F] was also tested to SS-1: Section 2 to demonstrate the equivalent fixed immersion available from that type of support surface.

Test	Purpose	Test Method
S3I Immersion SS-1:2019 Section 2	Measure immersion into the full body support surface.	Measure depth of sinking of a rigid mannequin (Fig 4) into the surface.
S3I Immersion SS-1:2019 Section 6	Measure immersion characteristics of the support surface.	Specialized indenter (Fig 5) measures localized immersion in the sacral region.

Table 1. Description of test methods

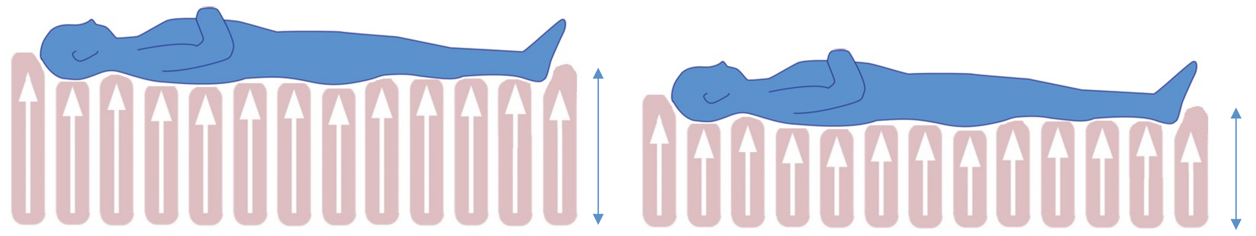

Fig 2. Example of lower and higher immersion levels / patient heights using different mode settings of a surface

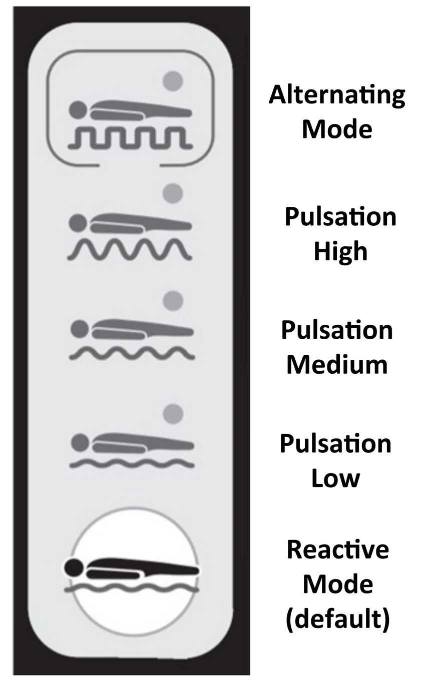

Fig 3. Available modes

Fig 4. SS1: Section 2 Rigid Test Mannequin

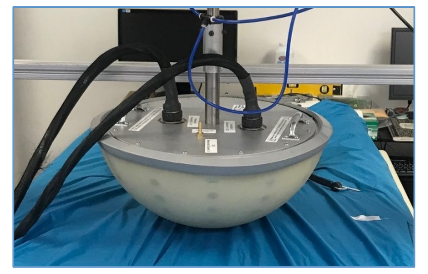

Fig 5. SS-1: Section 6 Hemispherical indenter

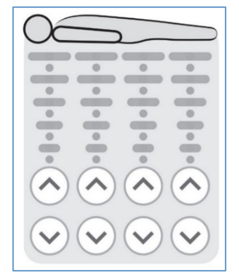

Fig 6. Four Zone pressure adjustment

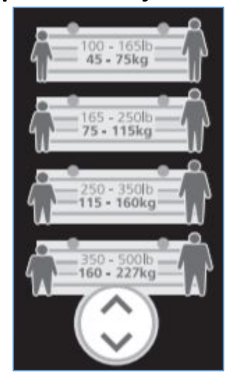

Fig 7. Patient size/weight preset adjustment options

Results

The immersion performance provided by the example patient support surface of Fig 1 is presented graphically in Fig 8 in terms of the absolute measurement (in mm). This shows the different operating modes and the results using the two different SS-1 test methods. This highlights the immersion level available to be decreased or increased within each of the individual operating modes.

For comparison purposes , a foam-based reactive surface was also tested and this is also shown.

The immersion variation is shown in Fig 9 and was achieved by adjusting the pressure and size / weight controls (as shown in Fig 6 and Fig 7).

The SS-1: Section 2 immersion data is also presented as a percentage of the surfaces' height in Table 2.

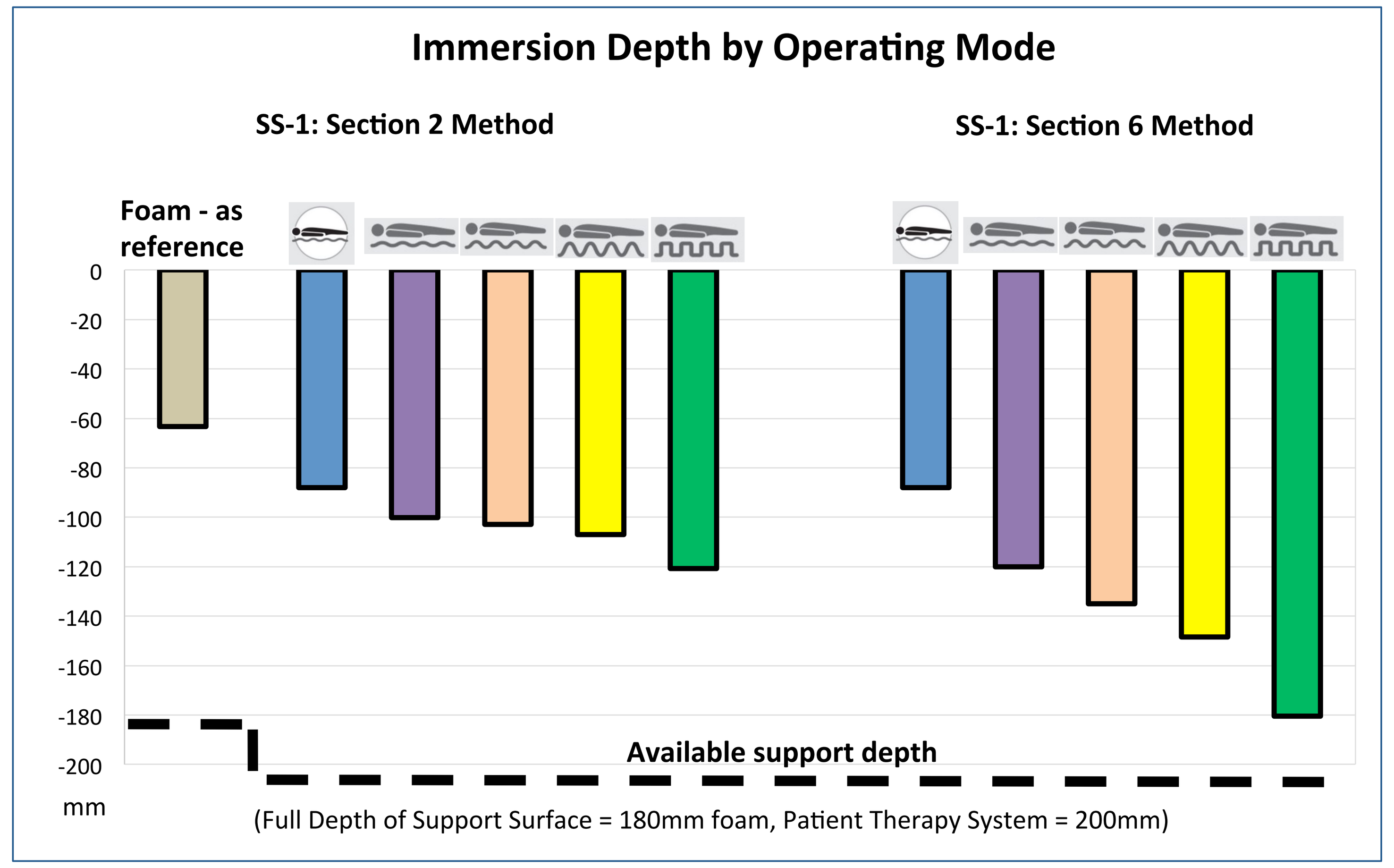

Fig 8. Examples of Varying Immersion by mode of operation and measured by 2 different test methods

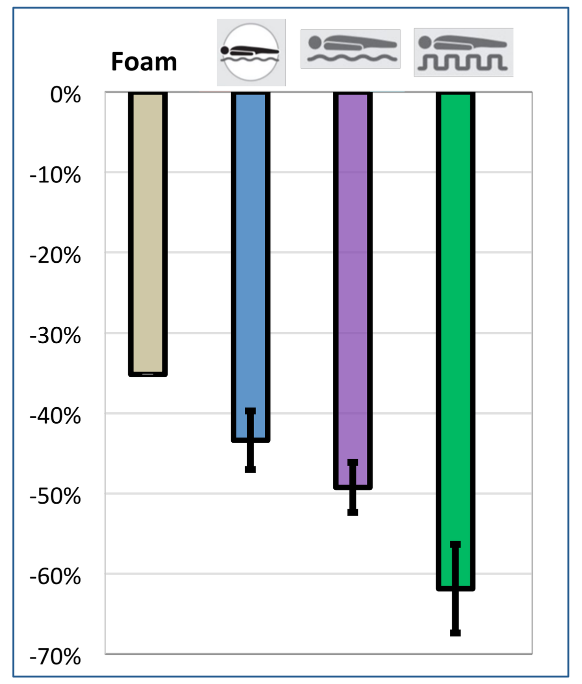

Fig 9. Section 2 test method data showing different immersion percentages for each operating mode.

(Adjustment achievable via the clinician controls is shown at the end of each bar)

Surface & Mode of Operation	Sacral Mean Immersion (in / mm) [4]	Sacral Mean Immersion (%)
Foam (7 inch height as a comparison)	2.49 / 63.2	35%
Air – Reactive (8 inch / 200mm high)	3.47 / 88.1	43%
Air - Pulsation Low (8 inch / 200mm high)	3.94 / 100.0	49%
Air – Alternating (8 inch / 200mm high)	4.95 / 125.7	62%

Table 2. Section 2 test method data showing varying immersion.

Discussion

The aim of the investigation was to quantify the immersive effect of varying the surface operating mode and to simulate the adjustment benefits available in clinical use utilizing accepted US national test methods. This work provides a link between the engineering design of support surfaces, the use of US national test standards and providing advice on the available options for the use of a support surface in clinical practice.

The two different immersion tests involve different effects in terms of the loading applied to the support surface. Both tests have their limitations compared to the joint structures present with a human body, as a result the depth of immersion can never be fully representative of a human body. However both tests provide useful insights into the immersion response of a support surface.

The results of the tests show clearly the similarities in the immersion effects and demonstrate the relationship between the available operating modes in terms of ranked immersion depth.

The adjustment of the surface settings can be used for specific clinical and comfort benefits such as:

- Increased immersion (and hence envelopment) enhances pressure re–distribution resulting in lower interface pressure to the skin.
- Increased immersion can improve patient positional stability in the support surface, helping to centralize the patient.

This demonstrates an advantage of air-based system over a foam mattress. The air system offers different modes providing a varying immersion capability compared to the fixed immersion provided by the foam.

The clinician can progressively adjust the support surface settings to optimally match the patients condition and needs. One mode may not be optimal for all phases of the care of an individual patient. For example, as mobility increases and time out of bed increases, the immersion level can be reduced by either changing the operating mode to a lower immersion mode or by adjusting the pressure levels.

Specific patients with particularly critical wounds or skin issues (such as burns victims) may benefit from the lower interface pressure that comes with increased immersion and lower operating pressures.

It is proposed that there are two distinct controls available to the clinician to select and vary the immersion provided by a support surface:

a) A primary control based on the selected mode of operation of the support surface.

b) A secondary control based on the adjustment of pressure / weight setting within any given mode of operation to provide for patient-specific immersion adjustments.

A yet further level of finer adjustment is possible within any of the 4 zones, our analysis shows the effect specifically on the immersion level in the sacral region, which is a known critical area for pressure injuries.

The increased immersion level provided by the alternating pressure mode (shown in Table 2) offers a further benefit to this mode that has not been reported previously and is worthy of further study.

Additionally, currently there is no standardized national or international test specifically for alternating pressure, however there is some standard development activity in this area. The use of immersion testing therefore also forms a useful comparison between the performance of reactive and active support systems.

Conclusions

The immersion level can be used as a parameter to adjust the performance of a support surface and the resulting care provided to a patient. Immersion (and the associated envelopment) is only one aspect of the provision of pressure injury management, however it is an important parameter in the operation, performance and use of a support surface that can be adjusted during patient use.

This work provides an example of connecting the work of industry in using the S3I standards and test methods to aid and guide clinical practice to the benefit of the patient.

References

1. ANSI/RESNA SS-1:2019 Volume 1: Requirements and Test Methods for Full Body Support Surfaces (Section 2, Section 6)
2. European Pressure Ulcer Advisory Panel, National Pressure Injury Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treatment of Pressure Ulcers/Injuries: Clinical Practice Guideline. The International Guideline. Emily Haesler (Ed.). EPUAP/NPIAP/PPPIA; 2019.
3. Arjo Inc, Citadel C200 Patient Therapy system Operating Manual
4. Arjo Inc, data on file ref: 100059436

Acknowledgments / Affiliations

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B. This poster is an industry-sponsored research activity, provided by Arjo Inc.
C. The integrated bed / patient support system used in this research was the Arjo Citadel C200.
D. Element Materials Technology, St Paul, MN,USA.
E. EC Service Corp, Centerville, UT,USA.
F. The foam surface tested was Therarest VE, Arjo Inc
G. Fig 4 Mannequin image courtesy of S3I and Element Material Technology.
H. Fig 5 Hemispherical Indenter courtesy of S3I and EC Service.

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