The Selection, Use and Accuracy of Alginate Impression Materials

Stan Presley, DDS and Jaimee’ Morgan, DDS

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Written for dentists, hygienists and assistants
Elastic impression materials include alginate, as well as the silicone and polyether materials that offer high levels of precision and detail. Recently, next-generation alginates and alginate substitutes have become available. These retain the advantages of traditional alginates and avoid some of their disadvantages. Alginates are the most-used impression material in the dental office, and while they seem basic, achieving good alginate impressions, whether with standard or next-generation materials, requires attention and a standardized technique involving good tray selection, mixing of the alginate, impression taking and pouring of the stone or plaster model.

The overall goal of this article is to provide the reader with information on impression materials, and specifically the use of impression materials for study models and appliance fabrication. On completing this article, the reader will be able to do the following:

1. List the categories of impression materials
2. List and describe the advantages and disadvantages of available types of impression materials
3. Describe the considerations when selecting a tray for alginate impressions
4. Delineate the difference between hand and mechanical mixing of alginates and results obtained
5. Review the clinical and laboratory processes by which alginate impressions are taken and poured.

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Introduction

A number of impression materials are available for use in the dental office. A primary consideration in determining which material is appropriate is the intended use of the impression. For all impression materials, desirable properties include accuracy, dimensional stability, a pleasing smell and taste, the shortest setting time that is suitable for a given procedure, and easy removal of the set impression. With elastomeric impression materials being the most popular, they fall into two categories: aqueous hydrocolloids (alginates and agars) and non-aqueous rubber (polysulfides, silicones, and polyethers) materials (Figure 1).

Non-aqueous Elastomeric Impression Materials

Non-aqueous elastomeric impression materials include polysulfide, polyether, condensation silicone, and addition silicone (vinyl polysiloxane). These are high precision and essential for impressions that will be used for the fabrication of indirect restorations and laboratory fabricated aligners. Since these materials do not absorb or lose water (with the exception of polyether material), they are dimensionally stable and allow for delayed pouring of stone. They are, however, more expensive to use. Labs prefer these due to their long term stability. Vinyl polysiloxane (VPS) and polyether (PE) materials are available in faster and slower setting variants, light to heavy body viscosities, and can be used in either a full or partial tray (Table 1) depending on the clinical case and preference. Requirements for non-aqueous elastomeric materials include an adequate working time; a range of suitable viscosities (thin, medium, thick and putty); a set hardness that is compatible with the tray type used (the strain-in-compression property of the material); highly precise replication of details (preparations, margins and adjacent soft tissue); elastic recovery; excellent tear strength; and stability of the set impression until a model can be produced. These materials offer a long deformation-free window prior to model pouring, and allow multiple pours if necessary. All of these properties are necessary for accurate replication. PE impressions are taken using a one-stage technique. VPS, which is an addition silicone, can be used in either a one stage or two stage technique (where two layers of different viscosities are used for the impression). It should be noted that VPS materials should not be poured immediately, as they require at least one hour to “de-gas” hydrogen and avoid porosities in the resulting model.

There are some disadvantages to using these impression materials for full-arch impressions that will be made on unprepped teeth and used for models for fabricating sports mouthguards or custom trays. Due to the expense, relatively long setting time, and the amount of material needed for full arch impressions, this family of impression materi-
als is not generally recommended when creating models for in-office use. The set silicone can be a challenge to remove from the mouth which can be uncomfortable for the patient. Equally challenging is removing the set model without breakage.

**Aqueous Elastic Impression Materials**

Agar and alginate are both aqueous elastic impression materials. Agar is a highly precise reversible hydrocolloid that has many uses in fixed and removable prosthodontics. It has been in use since Sears created it in 1937 and consists of 85% water and 15% agar. However, this material is difficult to handle and requires use of a heating device to render a viscosity suitable for impression taking. A water-cooled tray must be used while taking the impression, after which the agar reverts to a solid state upon cooling. A further issue is that it is generally recommended to pour reversible hydrocolloid impressions immediately due to dimensional instability. Reversible hydrocolloids are now less frequently used in the United States for impressions.

**Alginate Impression Materials**

Alginate was originally developed by the US Navy as a replacement for agar during World War II, when agar became unavailable. It is the most frequently used impression material, used for study models as well as models for the fabrication of appliances, bleaching trays and indirect provisional restorations. Alginites consist of a powder containing sodium alginate or potassium alginate, calcium sulphate, trisodium phosphate, filler (diatomaceous earth), zinc oxide and potassium sulphate, plus flavoring and coloring agents; this powder is mixed with water. The sodium alginate and calcium sulphate react chemically to produce sodium sulphate and calcium alginate, and the trisodium phosphate is added to retard the setting reaction and give sufficient working time for the impression.

Advantages of alginates include their ease of use, hydrophilicity and therefore tolerance of the presence of moisture, low cost, and ability to be used in stock trays. They are suitable for full-arch impressions and easy to remove from undercuts and unprepped teeth. Traditional disadvantages, however, have included a low tear strength, porosities in the surface of the poured models, a low level of detail (although usually adequate for the intended purpose) and generally poor results if the impression is reused after the pouring of one model. In one laboratory study, however, it was found that if impressions were stored properly, a second pour was possible if this occurred within 45 minutes of the impression being taken. Poor dimensional stability may also be a disadvantage, particularly if set alginate impressions are improperly stored (rapidly drying out if left out after setting and the potential for absorption of liquids). One recent bench study found that provided they were properly stored, models poured from 5-day-old alginate impressions were still accu-

<table>
<thead>
<tr>
<th>Table 1. Characteristics of elastomeric impression materials</th>
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<tbody>
<tr>
<td>High precision</td>
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<tr>
<td>Excellent capture of details of preparations and adjacent soft tissue</td>
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<tr>
<td>Good elastic recovery</td>
</tr>
<tr>
<td>Good dimensional stability</td>
</tr>
<tr>
<td>Enable multiple pours</td>
</tr>
<tr>
<td>Available in different viscosities</td>
</tr>
<tr>
<td>Relatively long setting times</td>
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<tr>
<td>Available with various setting times (material dependent)</td>
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rate for diagnosis and fabrication of appliances. It is generally recommended to either pour alginate impression materials immediately or store them in a damp towel for a short period of time while transporting them to the laboratory. (Table 2)

Recent developments

Newer impression materials have been introduced to address the shortcomings of traditional alginate materials, while retaining its advantages as well as achieving some of the advantages of non-aqueous elastomeric impression materials. Recent additions include vinyl polysiloxane “alginate substitute” materials that are mixed with an automix tip, are dimensionally stable, and allow for multiple pours. Compared to alginate impression material, these alginate substitutes have been proven to have greater tear strength, greater detail reproduction, and less outgassing and model porosity. At the same time, these are faster setting than traditional VPS and less expensive.

A further development has been the introduction of a next-generation alginate impression material that is heavy-bodied to help move the peripheral tissues out of the way and capture the anatomy of the dental arch in question without slumping. Compared to typical alginites, it claims to offer improved dimensional stability (2 or 5 days’ dimensional stability), a reduced setting time (45 or 60 seconds), easier removal after setting and the ability to double pour models. A second (or double) pour is routinely performed when fabricating models for aligners. The model from the second pour is useful to track the orthodontic movement from the clear aligners throughout treatment, as well as providing a backup model in the event the patient loses an aligner.

Keys to Successful Alginate Impressions

Dental assistants need to be the métière of impression taking and model pouring to ensure well-fitting appliances. However, there are several alginate impression techniques being used in any office, depending on the number of people who take them. There are basically six keys to success in obtaining an impression that will produce an accurate model, as shown in Table 3.

Tray Selection

The most common full-arch impression trays are plastic and stainless steel rim lock trays (Figure 2). Disposable Styrofoam™ trays are traditionally used by orthodontic offices when impressions are sent to a lab for archival model fabrication. Because of their design, these trays are able to record the vestibule (Figure 3). Some of the disadvantages of Styrofoam™ trays include: 1) An alginate adhesive should be applied prior to use; 2) they can be expensive; 3) because they are more size specific, a larger inventory will be required which could also cause storage challenges; and 4) when a heavy bodied alginate is used, these trays may crack. Stainless steel rim lock trays are still regarded as the gold standard in dentistry. The extensive number of perforations in the tray, combined with the rim lock design, offers great anchorage for a heavy-bodied alginate, with no adhesive required. Plastic trays are available in two basic designs. Those with small round holes are designed for silicone impression materials and are very

Table 2. Characteristics of traditional alginate materials

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
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<tbody>
<tr>
<td>Easy to use</td>
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<tr>
<td>Moisture tolerant</td>
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<tr>
<td>Lower level of detail – sufficient for study models, and models for appliances</td>
<td></td>
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<tr>
<td>Require careful storage to prevent shrinkage or liquid sorption after setting</td>
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<tr>
<td>Easy to remove set impression from undercuts and unprepped teeth</td>
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<tr>
<td>Low tear strength</td>
<td></td>
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<tr>
<td>Single pour only</td>
<td></td>
</tr>
<tr>
<td>Available with various setting times (varies with amount of retarder)</td>
<td></td>
</tr>
<tr>
<td>Low cost</td>
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useful in crown and bridge procedures. However, they prove untrustworthy when heavy-bodied alginate is used, because the holes are too small for the material to extrude properly (Figure 4). When the impression is removed from the mouth, there can be a pull-away of the alginate from the tray, which will create distortion if it goes unnoticed. Plastic trays that have slots are ideal for heavy-bodied alginate. The slots allow for extrusion of the viscous material, which offers excellent retention (Figure 5). In fact, one study found stock plastic trays resulted in less linear discrepancy of alginate impressions than did stock metal trays.\textsuperscript{11}

Besides the material the impression tray is made of, size matters. The proper size tray will provide enough space for the impression material enough room for the alginate to record an imprint of the arch without allowing any show-through of the tray. The trays should be long enough to capture the hamular notches and the retromolar pads without impinging on the ramus of the mandible or the pharyngeal folds (Figure 6).\textsuperscript{12} When the proper match between tray and material is obtained, adhesive is not required.

The tensile bond strength between the tray and impression material determines whether or not the impression separates from the tray during removal from the patient’s mouth. If the use of adhesive is a personal preference, research has shown an increase in tensile bond strength and therefore a reduction in separation of the material from the trays.\textsuperscript{13}

<table>
<thead>
<tr>
<th>Table 3. Keys to successful alginate impressions</th>
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<tbody>
<tr>
<td>Tray selection</td>
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<tr>
<td>Choosing the appropriate material</td>
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<tr>
<td>Proper mixing of the material</td>
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<tr>
<td>Tray insertion and position in the mouth</td>
</tr>
<tr>
<td>Handling of impression prior to pouring the model</td>
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<tr>
<td>Selection and mixing of the gypsum product</td>
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Proper Mixing of Alginate

Hand mixing of alginate impression materials has been the accepted technique since its introduction. However, hand mixing relies on the accuracy of the person measuring out the powder and water and mixing the alginate, as well as thorough mixing for the correct length of time. Recent research has shown a positive improvement in the quality of the mix when mechanical means are used, as well as improvements in the elastic recovery and compressive strength of the resulting alginate impressions, which in turn improve the accuracy of the impression material.\textsuperscript{14,15} Almost no porosities were found in alginate that was mixed with an automatic alginate mixer, and the researchers concluded that the standardization of the mix was preferred over traditional hand mixing.\textsuperscript{14,16}

Options available for mechanical mixing of alginates include an automated vacuum mixer, an automated centrifugal-spinning mixer and a semi-automated mixer that requires hand mixing of alginate in an automatically rotating bowl. It was reported in one study that the centrifugal mixer and vacuum mixer resulted in significantly fewer porosities than the semi-automated mixer.\textsuperscript{17}
Mechanical mixers could also be considered “equalizers” for full-time or experienced staff members in comparison to part-time or inexperienced staff members. Mechanical mixing enables any staff member (or dental professional) to make a perfect mix every time and also reduces the need for cleanup. After mechanical mixing, the impression tray that has been preselected for the best fit is loaded with the impression material and inserted into the patient’s mouth.

Considerations in selecting a mechanical mixer include the degree of automation, ease of use and mixing protocol, reliability of mixing and results, portability of the device (whether it can be moved easily from one operatory to another), cost of the mixing equipment, any installation requirements (e.g., a vacuum line for vacuum mixers, and for which an existing office without a vacuum line would need to be retrofitted), and the ease of cleanup after mixing of the alginate. From a clinical standpoint, when these authors introduced mechanical mixing into their office about 6 years ago, the improvement in the impressions was immediately noticed. The resulting models provided better overall fit in the appliances made from them and decreased the number of remakes of appliances tremendously. The use of a mechanical auto mixer (TurboMAX®) is shown below. Mixing is standardized and uses distilled water, which has fewer impurities than tap water. The amounts of powder and water are measured into the mixing cup, and the lid is closed and then locks while mixing occurs under centrifugal force (Figures 7-9).

Figure 3. Styrofoam tray

Figure 4. Plastic tray with small round holes. This provides poor alginate retention.

Figure 5. Plastic tray with slots, enabling extrusion of the material for retention and excellent results

Figure 6. Capture of all anatomical details

Figure 7. Mixing cup with measured powder and water

Figure 8. Mixing cup in the mechanical mixer, closing the lid
Tray Positioning

Proper tray positioning ensures a greater chance of success. The causes of error that may appear at this stage in the protocol include: 1) Incorrect tray size; 2) improper tray positioning; and/or 3) poor capture of the vestibular area. Examining the resulting impression to ensure there is no show-through of the tray in the impression is critical to the success of the model and the appliance. In this picture there is both show through from an improperly seated impression as well as an air void where the anterior vestibule should be (Figure 10).

On tray insertion, results are more predictable when the assistant stands behind the patient for upper impressions, and in front of the patient for lower impressions. This allows for an easier approach of the free hand, allowing the assistant to retract the lip away from the teeth during tray insertion. With this method, the alginate material will not be blocked out of this important area and all of the vestibular area can be captured. Another method is to first insert cheek retractors (Figure 11). This gives the assistant the best view of all vestibules. When the tray is inserted, it becomes very easy to position the tray properly; the tray flanges push up or down on the retractors and provide all the space needed for a perfect
impression (Figures 12-13). When inserting a lower tray, it is also helpful to ask the patient to lift his or her tongue toward the palate and then to bring the tongue back into position—this enables placement of the tray to capture all soft-tissue contours lingually.

**Mixing Stone for Models**

There are a variety of gypsum products available for fabricating models. If appliances such as removable partial dentures, orthodontic retainers or clear aligners are being fabricated, die stone is preferable because it provides excellent detail and hardness. Die stone can be purchased in unidose packets, which offer convenience but can also be expensive. Stone purchased in bulk is more economical, but its use has the reputation for inattentive measuring by users (e.g., evidenced by the use of a plastic cup and a trickle of water from the faucet until it seems to be the correct viscosity). The success of the study model (or appliance) depends on a rigid although easy protocol that includes following the manufacturer’s powder/liquid ratio instructions. A convenient and inexpensive way to ensure that the correct amount of powder is being used is to premeasure the powder and place single premeasured doses in plastic containers that are always ready to use when an impression is being poured up (Figures 14-15).

Having two different-sized containers can be very helpful, so that a single or double premeasured dose is available depending on whether one or two impressions are being poured. A larger container can hold 150 g of powder, which will pour two impressions, while a smaller container can hold 100 g of powder, which will pour one impression. The proper protocol for impression pouring requires the assistant to rinse the impression under a powerful water stream. The excess water is shaken from the impression and debubber is sprayed into the impression prior to the pour. The impression is set aside while the assistant measures the water into the flexibowl that contains the premeasured die stone. The die stone and water are then spatulated to a creamy mixture. A vibrator is then used to pour the stone into the impression, and the stone is left to set. The resulting models can generally be separated in about 30 minutes and are ready for use. Once the stone model has set, it should be removed within 1 hour from the alginate, as failure to do so can result in imperfections on the stone model.18

**Conclusions**

Following proper protocol in any dental procedure increases the potential for a successful outcome. Certainly when fabricating appliances, every step counts. Even one misstep during the process can result in an appliance that does not fit. In turn, this is discovered when the non-fitting aligner or appliance is tried-in at the delivery appointment, costing time and money and eroding patient confidence.
With the selection of the appropriate impression material and impression technique, impression taking is reliable and reproducible, with consistent successful results.

Glossary of Terms

Compressive strength: The ability of a material to resist compressive stress without fracturing

Elastomeric: A polymer that has elastic properties

Elastic recovery: The ability of a material to rebound to its original shape after being deformed

Hydrophilicity: The affinity of a material for water

Outgassing: The release of embedded gas (or occluded gas) from a material

Tear strength: The ability of a material to resist tearing

Tensile bond strength: The ability of a material to resist being separated from material (i.e., being debonded)

References


Webliography


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**CEQuiz**

1. The ______ is a primary consideration in determining which impression material is appropriate.
   a. expense
   b. intended use of the impression
   c. atmosphere
   d. all of the above

2. ______ is a desirable property for an impression material.
   a. A pleasing smell and taste
   b. The shortest setting time suitable for a given procedure
   c. Easy removal of the set impression
   d. all of the above

3. ______ is an elastic impression material.
   a. Plaster of Paris
   b. Wax
   c. Compound
   d. none of the above

4. Elastic impression materials are ______.
   a. all aqueous
   b. all non-aqueous
   c. inaccurate
   d. none of the above

5. Addition silicone is an example of ______ impression material.
   a. an elastomeric
   b. a reversible hydrocolloid
   c. a non-aqueous
   d. a and c

6. ______ is used as a material for high-precision impressions for indirect restorations.
   a. Compound
   b. Vinyl polysiloxane
   c. Alginate
   d. all of the above

7. Addition silicone (VPS) impression materials ______.
   a. are dimensionally stable after setting
   b. do not imbibe water
   c. allow for multiple model pours
   d. all of the above

8. The set hardness of an impression material should be compatible with ______.
   a. saliva
   b. the tray that will be used
   c. the particular gypsum that will be used
   d. none of the above

9. Vinyl polysiloxane ______.
   a. can be used with a one-stage or a two-stage technique
   b. is relatively low-precision
   c. is a polyether
   d. a and c

10. The details of the ______ can be captured using a highly precise impression material.
    a. soft tissue adjacent to preparations
    b. margins
    c. preparations
    d. all of the above

11. A set impression should remain stable until the ______.
    a. patient goes home
    b. impression reaches the laboratory
    c. models and dies, as appropriate, are poured
    d. none of the above

12. It can be difficult to remove a full-arch impression of unprepped teeth taken with ______.
    a. agar
    b. alginate
    c. vinyl polysiloxane
    d. all of the above

13. Agar as an impression material ______.
    a. can be used with a one-stage or a two-stage technique
    b. is relatively low-precision
    c. is a polyether
    d. a and c

14. A water-cooled tray must be used when taking ______ impression.
    a. an alginate
    b. an agar
    c. a silicone
    d. none of the above

15. ______ is the most frequently used impression material.
    a. Polyether
    b. Silicone
    c. Alginate
    d. none of the above

16. Trisodium phosphate is added to alginate power to ______.
    a. accelerate the setting reaction
    b. improve the viscosity of the material
    c. retard the setting reaction
    d. b and c
17. Alginates consist of a powder in which one of the ingredients is ________.
   a. potassium alginate
   b. sodium alginate
   c. calcium alginate
   d. a or b

18. If a set alginate impression is left out on the bench after the impression has been taken, ________.
   a. it may shrink
   b. this will increase the tear strength
   c. this will increase the surface hardness for pouring the stone model
   d. b and c

19. “Alginate substitute” materials that have been introduced ________.
   a. are vinyl polysiloxanes
   b. are dimensionally stable
   c. allow for multiple pours
   d. all of the above

20. A next-generation alginate impression material is available, and ________.
   a. is heavy-bodied to help move the peripheral tissues out of the way
   b. captures the anatomy of the dental arch without slumping
   c. allows for a double pour
   d. all of the above

21. ________ is key to successful alginate impressions.
   a. Choosing the appropriate tray and material
   b. Proper mixing and handling of the material during and after impression taking
   c. Proper tray insertion and positioning in the mouth
   d. all of the above

22. ________ are the most common full-arch impression trays.
   a. Styrofoam and stainless steel rim lock trays
   b. Plastic and stainless steel rim lock trays
   c. Styrofoam and plastic
   d. none of the above

23. Plastic trays that have slots are ideal for ________, and the material can extrude through the slots.
   a. putty thickness impression material
   b. moderate-viscosity alginate
   c. heavy-bodied alginate
   d. none of the above

24. A positive improvement in the quality of an alginate mix has been found when ________.
   a. extra water is added
   b. less water is added
   c. mechanical mixing is used
   d. b and c

25. ________ is an option for a mechanical mixer for alginate.
   a. A semi-automated mixer
   b. An automated centrifugal-spinning mixer
   c. An automated vacuum mixer
   d. all of the above

26. ________ can lead to impression errors, which will result in inadequate models.
   a. Incorrect tray size
   b. Improper tray positioning
   c. Poor capture of the vestibular area
   d. all of the above

27. On tray insertion, results are more predictable when the assistant stands in front of the patient for ________.
   a. upper impressions
   b. lower impressions
   c. double impressions
   d. a and b

28. First inserting cheek retractors before taking an impression gives the assistant the ________.
   a. least chance that the patient will gag
   b. least chance that the patient will vomit
   c. best view of all vestibules
   d. all of the above

29. Die stone is preferable when the model will be used for ________ because it provides excellent detail and hardness.
   a. clear aligners
   b. orthodontic retainers
   c. removable partial dentures
   d. all of the above

30. With the selection of the appropriate impression material and impression technique, impression taking becomes ________.
   a. reliable
   b. reproducible
   c. consistently successful
   d. all of the above
CE ANSWER FORM (E-mail address required for processing)

Name: 
Title: 
Specialty: 
Address: 
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AGD Identification No. 

EDUCATIONAL OBJECTIVES
- List the categories of impression materials
- List and describe the advantages and disadvantages of available types of impression materials
- Describe the considerations when selecting a tray for alginate impressions
- Delineate the difference between hand and mechanical mixing of alginates and results obtained
- Review the clinical and laboratory processes by which alginate impressions are taken and poured

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Please evaluate this course using a scale of 5 to 1, where 5 is excellent and 1 is poor.

1. To what extent were the course objectives accomplished overall? 
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5

2. Please rate your overall mastery of the educational objectives? 
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5

3. How would you rate the educational methods? 
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5

4. A score of 70% will earn your credits. 
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5

5. Do you feel the references were adequate? 
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5

6. Would you participate in a similar course? 
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5

7. Was any subject matter confusing – please describe. 
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5

8.  Was any subject matter confusing – please describe. 
   - [ ] 1   [ ] 2   [ ] 3   [ ] 4   [ ] 5

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2. [ ] A   [ ] B   [ ] C   [ ] D
3. [ ] A   [ ] B   [ ] C   [ ] D
4. [ ] A   [ ] B   [ ] C   [ ] D
5. [ ] A   [ ] B   [ ] C   [ ] D
6. [ ] A   [ ] B   [ ] C   [ ] D

Please photocopy answer sheet for additional participants.

All fields marked with an asterisk (*) are required.

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