May 20, 2005

NMED No. 050183

Nancy Hellyer, Chief Executive Officer,
Trinity Health System
St. Joseph Regional Medical Center
South Bend Campus
Department of Nuclear Medicine
801 East LaSalle Street
South Bend, IN 46617-1935

SUBJECT: NRC AUGMENTED INSPECTION REPORT NO. 03013685/2005-001(DNMS)
ST. JOSEPH REGIONAL MEDICAL CENTER SOUTH BEND CAMPUS

Dear Ms. Hellyer:

The enclosed report refers to a special review by a Nuclear Regulatory Commission (NRC) Augmented Inspection Team (AIT) from March 31, 2005 through April 21, 2005, relative to the St. Joseph Regional Medical Center South Bend Campus' (the Medical Center's) report of two medical events involving manual, low-dose-rate brachytherapy treatments. The NRC's initial response to these issues began as a special inspection on March 30, 2005, following the Medical Center's report to the NRC of the events on March 28, 2005. The special inspection was upgraded to an AIT on March 31, 2005, following the identification of three additional patients that had similar treatments as those that resulted in the reported medical events. The AIT was composed of John R. Madera, Chief, Materials Inspection Branch, Region III (AIT Leader); Sami Sherbini, Ph.D., Senior Advisor for Health Physics, Office of Nuclear Materials Safety and Safeguards; Robert G. Gattone, Jr., Senior Health Physicist, Materials Inspection Branch, Region III; and Deborah A. Piskura, Health Physicist, Materials Inspection Branch, Region III. The report also refers to the follow-up activities of your staff and to a discussion of our findings with Gary L. Perecko and others of your organization at an April 21, 2005, public meeting.

The enclosed copy of our AIT report identifies areas examined during the inspection. Within these areas, the inspection consisted of observations by the inspectors, interviews with personnel, and review of selected records and procedures.

The AIT was formed to assess information regarding the two medical events reported on March 28, 2005, and similar brachytherapy treatments conducted from January through March 2004. Specifically, the AIT examined the circumstances surrounding a total of five treatments, and the Medical Center's investigation of the circumstances surrounding the treatments. The AIT review also included an independent assessment of the treatments by an NRC medical expert consultant.

The AIT concluded that the five treatments resulted in medical events, as defined in Title 10 of the Code of Federal Regulations (CFR) Part 35. The five treated patients all received a radiation dose to the skin of the upper thighs (i.e., unintended treatment sites) that: (1) was more than 50 centigray (cGy) above the dose expected for those areas from the administration

defined in the written directive; and (2) was greater than 50 percent of the dose expected. The AIT determined that the root cause of these medical events was the use of radioactive sources by Medical Center staff that had a smaller diameter than specified in the instructions distributed with the brachytherapy applicator, which allowed the sources to move from their intended position within the applicator to a position that resulted in the unintended doses to the skin of the patients. The AIT also concluded that Medical Center staff did not report these events until approximately one year after they occurred due to a misinterpretation of the reporting requirements in 10 CFR Section 35.3045. Other contributing factors to these medical events were poor management oversight of the brachytherapy radiation safety program and inadequate procedures for brachytherapy administrations.

It is not the responsibility of an AIT to determine whether NRC rules/requirements were violated, or to recommend enforcement actions. These aspects will be reviewed in a subsequent inspection.

In accordance with 10 CFR Section 2.390 of the NRC's "Rules of Practice," a copy of this letter and its enclosures will be available electronically in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). The NRC's document system is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html.

Sincerely,

/RA/
James L. Caldwell
Regional Administrator

Docket No. 03013685
License No. 13-02650-02

Enclosures: 1. Inspection Report 03013685/2005-001(DNMS)
2. AIT Charter

cc w/encls: Gary L. Perecko, President
John D. Scheu, Ph.D., RSO

bcc w/encls: Cynthia Flannery, Team Leader, IMNS
Ronald Zelac, Sr. Health Physicist, IMNS

See Attached Distribution:

*by telephone

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REGION III

Docket No.	03013685
License No.	13-02650-02
Report No.	03013685/2005-001(DNMS)
Licensee:	St. Joseph Regional Medical Center South Bend Campus
Locations:	801 East LaSalle Street, South Bend, Indiana 707 East Cedar Street, South Bend, Indiana
Dates of Inspection:	March 31 through April 21, 2005
Inspectors:	John R. Madera, Chief, Materials Inspection Branch Region III (Augmented Inspection Team Leader) Sami Sherbini, Ph.D., Senior Advisor for Health Physics, Office of Nuclear Materials Safety and Safeguards Robert G. Gattone, Jr., Senior Health Physicist, Materials Inspection Branch, Region III Deborah A. Piskura, Health Physicist, Materials Inspection Branch, Region III
Approved by:	_____ John R. Madera, Chief, Materials Inspection Branch, Region III (Augmented Inspection Team Leader)
	_____ Marc L. Dapas, Director, Division of Nuclear Materials Safety, Region III

Enclosure (1)

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EXECUTIVE SUMMARY

St. Joseph Regional Medical Center South Bend Campus
NRC Inspection Report No. 03013685/2005-001(DNMS)

On March 28, 2005, the St. Joseph Regional Medical Center South Campus (licensee) staff reported to the Nuclear Regulatory Commission (NRC) its identification of two medical events involving radiation doses to unintended treatment sites of two patients. The licensee had administered brachytherapy treatments to the patients in February and March 2004 and, during a subsequent review, licensee staff determined that the treatments had resulted in medical events, as defined in the NRC's regulations. During a special NRC inspection conducted on March 30, 2005, to review the circumstances of the two medical events reported by the licensee, the inspector identified three additional patients that had similar treatments as those that resulted in the reported medical events, and one of those additional patients exhibited observable side effects. As a result, the NRC upgraded the special inspection to an Augmented Inspection Team (AIT) on March 31, 2005. The purpose of the AIT was to examine the conditions and circumstances surrounding the medical events to determine the probable causes and contributing factors of the events. The AIT concluded that five brachytherapy treatments had resulted in medical events as defined in Title 10 of the Code of Federal Regulations (CFR) Part 35. Three of the patients developed skin lesions on the upper thighs from radiation doses to the skin of the upper thigh, an unintended treatment site. The nature of the lesions indicated that the doses were greater than 50 centigray (cGy), and were greater than 50 percent above, the dose expected from the administration defined in the written directive. The other two patients did not exhibit any unintended radiation effects. Therefore, those two patients received an unintended dose to the thighs that was below the threshold for radiation effects. The AIT also determined that the root cause of these medical events was the use of radioactive sources by licensee staff that had a smaller diameter than that specified in the instructions distributed with the brachytherapy applicator, which allowed the sources to move from their intended position within the applicator to a position that resulted in the unintended doses to the skin of the patients. The following paragraphs summarize the team's findings in each of the AIT charter areas.

The team developed a time line and set of facts surrounding each of the five similar brachytherapy patient cases that were treated between January and March 2004. The time line and set of facts developed by the licensee for the same five brachytherapy patient cases agreed substantially with the team's. The team did not identify any additional medical events involving the licensee's use of the applicator prior to January 2004 or after March 2004.

The instructions provided by the manufacturer of the applicator were inadequate. The instructions did not provide adequate caution statements regarding the physical dimension requirements of sources to be used in the applicator. Although the instructions specified the use of a certain manufacturer's sources, which would have been adequately held in the proper position by the spring employed in the tandem portion of the applicator, the instructions did not provide sufficient specificity regarding the physical dimension requirements of the sources to be used. Furthermore, the instructions permitted the use of other manufacturers' sources, but did not provide cautions regarding the use of sources that were of a smaller diameter than those from the specified source manufacturer. The licensee and the authorized user relied on

contract medical physicists to self-instruct and familiarize themselves with the applicator prior to its use. A contract medical physicist involved in the five brachytherapy treatments was not familiar with the use of the particular applicator and did not recognize that the two sets of brachytherapy sources possessed by the licensee were physically different in a critical dimension. Neither the licensee nor the authorized user provided specific instructions to the contract medical physicists regarding technical limitations associated with the use of the applicator. The licensee's poor supervision of contract medical physicists was a contributing factor to the medical events.

Licensee staff did not follow the instructions provided with the applicator because they failed to thoroughly read them. The instructions specified the use of sources manufactured by the 3M Company (3M) and the applicator was marked with the appropriate source dimensions. During each of the five brachytherapy treatments that resulted in medical events, the contract medical physicist selected G.E. Healthcare (formerly known as Amersham) (Amersham) sources for use in the applicator. However, the physicist assumed that all of the sources were manufactured by 3M and did not recognize that he had selected sources from a different manufacturer. In addition, the physicist did not recognize that the difference in source dimensions could impact their use in the applicator. Therefore, since he failed to thoroughly read the instructions and failed to recognize that the licensee possessed two sets of sources that were different in a critical dimension, he used Amersham sources in the applicator that were too small in diameter.

The scope and thoroughness of the licensee's dose assessments for the five patients in question was adequate. Licensee contract medical physicists referenced published examples of radiation injuries to estimate the doses delivered to the thighs of each patient. The dose estimates ranged from approximately 1,000 cGy for those patients who did not exhibit any observable side effects (Patients 1 and 2), to a maximum of 2,000 cGy for those patients who exhibited the most severe effects (Patients 3 and 5). The methodology employed by the physicists was reasonable considering the lack of other definitive information on which to base dose calculations.

The team calculated the dose rates for each of the patients, and used the total dose estimates based on the appearance of the skin lesions to calculate the exposure durations. The licensee also used the appearance of the lesions to estimate the total dose received by each patient. However, the licensee estimated the durations of the exposures on the basis of interviews, and used these time estimates to calculate the dose rates. The team's dose rate estimates for Patients 3 and 4 were in very good agreement with those obtained by the licensee. However, the team's dose rate estimate for Patient 5 was substantially higher than that determined by the licensee. The team was unable to estimate doses for Patients 1 and 2, due to the lack of observable effects and it relied on the medical expert consultant's dose estimate. That estimate was based on the fact that any dose received by these patients must have been lower than the threshold for observable skin effects, which the consultant believed to be about 300 cGy. Based on the observable effects exhibited by each patient, the team determined that the inner thighs of Patients 3, 4, and 5 received approximately 2,000 cGy, 1,500 cGy, and 2,000 cGy, respectively.

The licensee's procedures for manual, low-dose-rate brachytherapy administrations were inadequate. The licensee 's procedures did not require verification that the sources used with the applicator were appropriate to administer the treatment as prescribed on the written directive. In addition, the licensee's procedures referenced obsolete requirements that existed prior to the April 2002 revision of 10 CFR Part 35. The licensee's use of inadequate procedures was a contributing factor to the medical events.

The licensee's identification and response to patient erythema (abnormal redness of the skin) and/or ulcerations included periodic examinations of Patients 3, 4, and 5, to assess their condition and healing. The licensee implemented effective corrective actions to the medical procedures to prevent similar medical events. However, the licensee did not promptly develop long-term corrective action.

The team identified two generic concerns. The instructions provided with the applicator were inadequate. In addition, the licensee's applicator spring did not have an inward bend to prevent source movement during brachytherapy treatments.

To prevent similar medical events, the licensee modified the applicator by using different hardware to hold the radioactive sources in place during brachytherapy treatments. The licensee's modification to the applicator was appropriate. The modification was not regulated by the Food and Drug Administration.

The licensee relied on the contract medical physicists to interpret NRC regulations regarding identification and notification of medical events. The licensee accepted the contract medical physicists' misinterpretation of 10 CFR Section 35.3045. In addition, when the Radiation Safety Committee members reviewed the events, they focused on the dose to the treatment site rather than dose to tissues or organs other than the treatment site that were 50 percent or more of the dose expected from the administration. The licensee's misinterpretation of the requirements in 10 CFR Section 35.3045(a)(3) resulted in the licensee's failure to promptly identify that five medical events occurred. Therefore, the NRC was not afforded an opportunity to promptly evaluate the events.

The Radiation Safety Officer's poor oversight of the brachytherapy radiation safety program significantly reduced his ability to: (1) ensure that radiation safety activities were performed in accordance with regulatory requirements; (2) identify radiation safety problems; (3) initiate, recommend, or provide corrective action; and (4) stop unsafe operations. The licensee relied on the contract medical physicists to monitor activities relative to the licensee's brachytherapy radiation safety program; however, the contract medical physicists were also delegated the responsibility for the day-to-day implementation of the brachytherapy radiation safety program. As a result, the licensee missed opportunities to identify precursors associated with five medical events (e.g., limitations on the sources that should be used with the applicator, a contract medical physicist's unfamiliarity with the two types of sources possessed by the licensee) and to promptly identify and report those medical events.

Report Details

1 Program Summary

Nuclear Regulatory Commission (NRC) License No. 13-02650-02 authorizes St. Joseph Regional Medical Center South Bend Campus (licensee) to use a variety of byproduct materials for diagnostic and therapeutic medical purposes, including cesium-137 sources for low-dose-rate gynecologic brachytherapy treatments. The licensee administered ten to fifteen gynecologic brachytherapy treatments per year utilizing various types of applicators. The licensee possessed two sets of brachytherapy sources, one manufactured by 3M Company (3M), the other by G.E. Healthcare (formerly known as Amersham) (Amersham). The licensee retained the services of a contract medical physics consulting group to provide medical physics support to the radiation oncology department.

2 Sequence of Events and Initial Licensee Response (Charter Item No. 1)

2.1 Inspection Scope

The Augmented Inspection Team (AIT) developed a time line and set of facts surrounding each of the five similar brachytherapy patient cases that were treated between January and March 2004. The team determined whether any additional medical events occurred before January 2004 or after March 2004. The inspectors interviewed selected individuals including an authorized user, selected contract medical physicists, and the Radiation Safety Officer (RSO). In addition, the inspectors toured brachytherapy facilities and examined selected brachytherapy equipment. The inspectors also reviewed selected records, including written directives, treatment plans, progress notes, and contract medical physicists' reports that pertained to the medical events.

2.2 Observations and Findings

a. Treatment of Patient 1

The licensee used a Mick Radio-Nuclear Instruments, Inc.'s Wang Front Loading Vaginal Applicator (Model 8524, Serial 030004) (applicator) with cesium-137 sources to treat Patient 1. The applicator design accommodated three sources. The instructions distributed with the applicator specified the use of radioactive sources manufactured by 3M. During treatments, one of the sources was placed into a hinged insert, referred to as a "bucket," and subsequently positioned within the applicator perpendicular to the remaining two sources that were positioned in the tandem portion of the applicator (reference Attachment A). The tandem sources were loaded into a flexible carrier tube and a spring was inserted into the tube to hold the sources in position (reference Attachment B). Once the sources were loaded into the flexible carrier tube, the tube was placed into the applicator (reference Attachment C). The applicator design allowed the three sources to be inserted into the applicator after the applicator had been positioned in the patient, thereby reducing the radiation dose to brachytherapy staff.

The licensee used the applicator to treat Patient 1 from January 26 to 27, 2004. For this treatment, the authorized user prescribed a radiation dose of 2,500

centigray (cGy) to the vaginal surface. To deliver the prescribed radiation dose, the physicist loaded a 3M source in the bucket and two Amersham sources in the tandem portion of the applicator. Patient 1 did not exhibit any observable side affects as a result of the brachytherapy treatment.

b. Treatment of Patient 2

The licensee used the applicator to treat Patient 2 from February 18 to 21, 2004. For this treatment, the authorized user prescribed a radiation dose of 6,500 cGy to the vagina. To deliver the prescribed radiation dose, the physicist loaded an Amersham source in the bucket and two Amersham sources in the tandem portion of the applicator. Patient 2 did not exhibit any observable side affects as a result of the brachytherapy treatment.

c. Treatment of Patient 3

The licensee used the applicator to treat Patient 3 from February 23 to 24, 2004. For this treatment, the authorized user prescribed a radiation dose of 2,850 cGy to the vagina. To deliver the prescribed radiation dose, the physicist loaded an Amersham source in the bucket and two Amersham sources in the tandem portion of the applicator.

On March 9, 2004, a nurse practitioner examined Patient 3 and observed moist desquamation (blister formation with drainage) on the patient's buttocks and upper thigh. The nurse practitioner suspected that the observed effects were dermatitis due to linear accelerator treatments received by the patient prior to the examination or contact dermatitis due to friction from radiation implant briefs that were used to hold the applicator in position during the branchytherapy treatment.

On March 18, 2004, the authorized user examined Patient 3 and observed dermatitis involving the vagina and perineum (the region between the genital area and the anus). The authorized user also attributed the dermatitis to either the linear accelerator treatments received by the patient or contact dermatitis due to friction from the radiation implant briefs that were used during the brachytherapy treatment. As a precaution, the authorized user requested that one of the licensee's contract medical physicists (Physicist A) investigate the cause.

On April 15, 2004, the authorized user examined Patient 3 and observed moist desquamation on the medial aspects of both upper thighs, with each lesion measuring about 4 centimeters by 3 centimeters. The authorized user did not attribute the skin lesions on Patient 3 to the linear accelerator treatments or the radiation implant briefs that were used to hold the applicator in position because the medial aspects of both upper thighs were outside of the linear accelerator treatment field and irritation from the radiation implant briefs should have healed by that time. Based on the clinical findings for Patients 3, 4, and 5, the authorized user suspected that the injuries to the patient's thighs were radiation-induced, as a result of the brachytherapy treatment.

d. Treatment of Patient 4

The licensee used the applicator to treat Patient 4, from March 1 to 2, 2004. For this treatment, the authorized user prescribed a radiation dose of 2,850 cGy to the vagina. To deliver the prescribed radiation dose, the physicist loaded an Amersham source in the bucket and two Amersham sources in the tandem portion of the applicator.

On March 22, 2004, the authorized user examined Patient 4 and observed an abrasion on the medial aspect of the upper left thigh. The medial aspect of the upper left thigh was out of the field where the patient had received linear accelerator treatments. The authorized user attributed the abrasion to friction from radiation implant briefs that were used to hold the applicator in position during the brachytherapy treatment.

On April 15, 2004, the authorized user examined the patient and observed an area of moist desquamation on the medial aspect of her left upper thigh measuring approximately 4 centimeters by 3 centimeters. Based on the clinical findings for Patients 3, 4, and 5, the authorized user suspected that the injuries to the patient's thighs were radiation-induced, as a result of the brachytherapy treatment.

e. Treatment of Patient 5

The licensee used the applicator to treat Patient 5 from March 19 to 22, 2004. For this treatment, the authorized user prescribed a radiation dose of 6,500 cGy to the vagina. To deliver the prescribed radiation dose, the physicist loaded an Amersham source in the bucket and two Amersham sources in the tandem portion of the applicator.

On April 12, 2004, the authorized user examined the patient and observed moist desquamation on the medial aspects of both upper thighs, with each lesion measuring approximately 5 centimeters by 4 centimeters. Patient 5 did not receive linear accelerator therapy. The authorized user attributed the lesions to friction from radiation implant briefs that were used to hold the applicator in position during the brachytherapy treatment. On April 15, 2004, the authorized user suspected that, based on the clinical findings for Patients 3, 4, and 5, the injuries to the patient's thighs were radiation induced, as a result of the brachytherapy treatment.

2.3 Conclusions

The team developed a time line and set of facts surrounding each of the five brachytherapy patient cases that were treated between January and March 2004. The time line and set of facts developed by the licensee for the same five brachytherapy patient cases agreed substantially with the team's. The team's evaluation of the licensee's response to the physical symptoms exhibited by Patients 3, 4, and 5 is described in Section 8 of this report. The team did not identify any additional medical events involving the licensee's use of the applicator prior to January 2004 or after March 2004.

3 Adequacy of the Applicator Instructions (Charter Item No. 2)

3.1 Inspection Scope

The AIT evaluated the adequacy of the instructions received with the applicator and the instructions from the authorized user regarding the type and model of sealed sources that are required to be used with the device. The inspectors reviewed the instructions that the licensee received with the applicator. The inspectors interviewed the authorized user for the subject brachytherapy treatments, a representative of the applicator manufacturer (Mick-Radio-Nuclear Instruments, Inc.), and a contract medical physicist.

3.2 Observations and Findings

a. Instructions from the Applicator Manufacturer

In the Fall of 2003, contract medical physicist B (Physicist B), trained Physicist A on the implementation of the licensee's brachytherapy program. At that time, Physicist B recommended that the licensee purchase the applicator. Physicist B recommended the applicator to the licensee because of its design for reducing the occupational radiation dose to brachytherapy staff, and because the authorized user favored the dose distribution associated with the use of the applicator.

On September 26, 2003, the licensee purchased the applicator from a brachytherapy equipment distributor. Physicist A was not aware of either the purchase or receipt of the applicator.

In January 2004, Physicist B's involvement with the licensee's brachytherapy program ended and Physicist A became the sole medical physicist involved with the licensee's brachytherapy program. At that time, Physicist A remained unaware that the licensee possessed the applicator. In addition, Physicist A did not have an adequate understanding of the licensee's inventory of brachytherapy sources. The licensee possessed two sets of sources: an older set manufactured by 3M and a newer set manufactured by Amersham. The 3M set included color-coding as a means of communicating radioactivity. The Amersham set included band markings as a means of communicating radioactivity. Both sets of sources were 2 centimeters in length; however, the diameter of the 3M sources was 3.1 millimeters, whereas the diameter of the Amersham sources was 2.6 millimeters. Physicist A assumed that both sets of sources had been manufactured by 3M and were of the same physical size. Physicist A also assumed that the licensee's non-radioactive (dummy) sources were the same physical size as all of the licensee's cesium-137 sources. However, the physical dimensions of the dummy sources were consistent with the physical dimensions of the licensee's 3M sources.

In January 2004, the authorized user requested the first brachytherapy treatment involving the use of the new applicator. Physicist A, not being aware that the licensee possessed the applicator in question, contacted Physicist B seeking assistance. Physicist B informed Physicist A of the location of the applicator and instructed Physicist A to read the instructions that came with it. In addition, Physicist B discussed the positioning of the sources in the applicator.

Portions of the instructions provided with the applicator indicated that only 3M sources should be used with the applicator. However, other portions of the

instructions indicated that the tandem portion of the applicator may be loaded with sources manufactured by other suppliers, and it referenced an attachment with source comparisons. The source comparisons attachment was not clear regarding what other sources could be used (e.g., it did not indicate the source manufacturers' names or the technical limitations on source physical dimensions). The instructions indicated that the applicator utilized three sources in a "T" configuration (e.g., one in the bucket and two in the tandem portion of the applicator). However, another section stated that up to four sources could be used in the tandem portion of the applicator.

The distal end of the applicator spring was designed with an inward bend to prevent source movement down the center of the spring. The instructions stated that the applicator spring could be shortened. This could be necessary if more than two sources were used in the tandem portion of the applicator. The licensee had not used more than two sources in the tandem portion of the applicator for any of the five similar brachytherapy treatments completed. Therefore, the licensee did not cut the applicator spring. The instructions did not provide a warning to the user not to cut the distal end of the spring with the inward bend, if shortening was necessary. Such an action could result in source movement down the center of the spring. The spring supplied with the licensee's applicator did not include the inward bend at the distal end, which increased the potential for source movement under certain circumstances. The team referred its observations regarding the applicator instructions to the Food and Drug Administration (FDA) for its review and evaluation.

b. Instructions from the Authorized User

The authorized user relied on the contract medical physicists to familiarize themselves with the technical limitations of the applicator, and to provide him with the technical limitations related to the use of the applicator. The authorized user expected the contract medical physicists to read the applicator instructions or contact the applicator manufacturer to obtain necessary additional technical assistance. The authorized user assumed that the contract medical physicists had read the applicator instructions. The authorized user was not familiar with the applicator instructions or the technical limitations regarding the use of the applicator until April 2004. The licensee's supervision of the contract medical physicists was limited and the licensee did not provide instructions to Physicist A regarding the technical limitations associated with the applicator prior to its first use.

3.3 Conclusions

The instructions provided by the manufacturer of the applicator were inadequate because they were unclear and contradictory. The instructions did not provide adequate cautions regarding the physical dimension requirements of sources to be used in the applicator. Although the instructions specified the use of a certain manufacturer's sources, which would have been adequately held in the proper position by the spring employed in the tandem portion of the applicator, the instructions did not provide sufficient specificity regarding the physical dimension requirements of the sources to be used. Furthermore, the instructions permitted the use of other manufacturers' sources, but did not provide cautions regarding the use of sources that were of a smaller diameter than those from the specified source manufacturer. The

licensee and the authorized user relied on the contract medical physicists to self-instruct and familiarize themselves with the applicator prior to its use. The contract medical physicist involved in the five brachytherapy treatments was not familiar with the use of the particular applicator and did not recognize that the two sets of brachytherapy sources possessed by the licensee were physically different in a critical dimension. Neither the licensee nor the authorized user provided any specific instructions to the contract medical physicists regarding the use of the applicator. The licensee's poor supervision of contract medical physicists was a contributing factor to the medical events.

4 Compliance with the Applicator Instructions (Charter Item No. 3)

4.1 Inspection Scope

The team evaluated the licensee's compliance with instructions/guidance provided by the applicator manufacturer and/or medical physics staff. The inspectors reviewed the instructions that the licensee received with the applicator and examined the applicator. The inspectors also interviewed an authorized user and a contract medical physicist.

4.2 Observations and Findings

Physicist A performed acceptance testing of the applicator prior to first use in an attempt to identify any potential problems associated with the use of the applicator. The acceptance testing included mechanical manipulation and radiographs of the applicator loaded with dummy sources. Since the dummy sources had the same diameter as the 3M sources, the physicist did not recognize that sources from other manufacturers (i.e., Amersham) with smaller diameters than the dummy sources could move down the center of the spring to the opposite end of the tandem portion of the applicator.

During acceptance testing, Physicist A read the instructions provided with the applicator with a focus on the isodose lines and sterilization recommendations. However, Physicist A did not notice that the instructions indicated that only 3M sources should be used in the applicator. In addition, Physicist A did not notice that the applicator was marked, "Cs-137 3.1 X 20 mm," indicating the diameter and length of sources to be used. As stated in Section 3, Physicist A did not have an adequate understanding of the licensee's inventory of brachytherapy sources.

4.3 Conclusions

Licensee staff did not follow the instructions provided with the applicator because they failed to thoroughly read them. The instructions specified the use of sources manufactured by 3M and the applicator was marked with the appropriate source dimensions. During each of the five brachytherapy treatments that resulted in medical events, the contract medical physicist selected Amersham sources for use in the tandem portion of the applicator. However, the physicist assumed that all of the sources were manufactured by 3M and did not recognize that he had selected sources from a different manufacturer. In addition, the physicist did not recognize that the difference in source dimensions could impact their use in the applicator. Therefore, since he failed to thoroughly read the instructions and failed to recognize that the licensee possessed two sets of sources that were different in a critical dimension, he used Amersham sources in the applicator that were too small in diameter.

5 Licensee Patient Dose Assessments (Charter Item No. 4)

5.1 Inspection Scope

The team evaluated the scope and thoroughness of the licensee's dose assessments for the five patients that were treated, based on the information available. The inspectors interviewed the authorized user, selected contract medical physicists, and the RSO. The inspectors reviewed the contract medical physicists' reports that pertained to the medical events, portions of a textbook on radiotherapy, and an article on radiation dose to skin.

5.2 Observations and Findings

a. Initial Dose Assessments

Following his examination of Patient 3 and his observation of the patient's injuries, the authorized user requested that Physicist A investigate the possible cause of the injuries in March 2004. During the investigation, Physicist A loaded the applicator with dummy sources and inverted it. The dummy sources remained in their intended position due to their physical similarity to 3M sources. Since the sources did not change position with the applicator, the physicist concluded that the patient's injuries were not due to unintended radiation received during the brachytherapy treatment.

In April 2004, after observing effects during examinations of Patients 3, 4, and 5, the authorized user requested that the contract medical physicist further investigate the possible cause of the injuries. During the second investigation, Physicist A reviewed the instructions that came with the applicator and noticed that the instructions specified the use of 3M sources. The physicist examined the licensee's two sets of brachytherapy sources and noticed that the two sets were marked differently (i.e., the "old" sources were color-coded and the "new" sources were banded). The physicist learned that the banded sources were manufactured by Amersham. Physicist A recognized that, contrary to the applicator instructions, Amersham sources were used in the applicator rather than the 3M sources during the treatments for the five patients.

Physicist A loaded the applicator with the Amersham sources and identified that the tandem sources slid down to the opposite end of the applicator's flexible carrier tube whenever the applicator was tilted more than 20 degrees off-level. At this point, the physicist recognized that the tandem sources moved out of their intended position whenever a patient moved more than 20 degrees off-level (e.g., sat up) during treatment, resulting in irradiation of the skin on the patients' thighs. Due to the design of the applicator, the bucket source remained in place. The Amersham sources moved through the center of the applicator spring because the diameter of the sources was smaller than the inner diameter of the applicator spring.

Physicist A then conducted a dose assessment for Patients 1 through 5 in April 2004. Physicist A contacted a senior member of the contract medical physics consulting group (Physicist C) for assistance. The physicists based their dose assessments on patient follow-up photographs of the skin lesions observed for

Patients 3 through 5. The physicists compared the size and severity of the lesions illustrated in the photographs with information contained in Gilbert H. Fletcher's "Textbook of Radiotherapy," to correlate moist desquamation with an estimate of absorbed radiation dose as a means of determining the doses received by the patients' thighs. Based on patient interviews, the physicists obtained information about how the patients' legs were positioned and for how long they remained in those positions during the treatments. With the estimates of the radiation dose to the patients' thighs determined from the textbook, and the known dose rates at the surface of the applicator, Physicists A and C determined the approximate time that the tandem sources were out of their intended position. By using those time estimates, the physicists were able to estimate the doses to the intended treatment sites.

Physicists A and C completed the dose assessments for Patients 1 through 5 in May 2004. They concluded that the greatest deviation from the prescribed dose was approximately 16 percent (Patient 5), and the smallest deviation from the prescribed dose was approximately 4 percent (Patient 2). The contract medical physicists determined that, for Patients 1 through 5, the source that was positioned in the bucket (reference Attachment A) would have provided a significant portion of the dose to the treatment site if all of the sources remained in the proper position; therefore, movement of the tandem sources did not significantly impact the dose delivered to the intended treatment sites.

The contract medical physicists concluded that the largest dose to the skin was 2,000 cGy (Patients 3 and 5). Patient 4 received chemotherapy which increased the patient's radiosensitivity. Therefore, the physicists determined that Patient 4 received 1,500 cGy to the skin. For Patients 1 and 2, the physicists estimated the maximum dose to the skin to have been 1,000 cGy. The physicists' estimate of 1,000 cGy to the skin for Patients 1 and 2 was based on a worst case assumption that 1,000 cGy was the dose threshold for erythema (abnormal redness of the skin) and Patients 1 and 2 exhibited no observable side effects from the treatments.

b. Subsequent Dose Assessments

During follow-up of Patient 3 on February 15, 2005, the authorized user observed a 1.5 centimeter ulcer on the medial aspect of the upper left thigh and necrosis due to devascularization measuring 1 centimeter on the medial aspect of the upper right thigh. Since the patient exhibited side effects that were more severe than previously observed, the authorized user requested that Physicist C reassess the doses for Patients 1 through 5.

For the reassessment, Physicist C referenced an article, titled, "Single Dose Irradiation Response of Pig Skin: A Comparison of Brachytherapy Using Single, High Dose Rate Iridium-192 Stepping Source With 200 keV X-Rays." The article was published in the July 2000 edition of the British Journal of Radiology. The article provided information correlating radiation dose received by pig skin with the incidence of erythema and moist desquamation. The results of the dose reassessment were comparable to the original dose assessment that was completed in May 2004.

5.3 Conclusions

The scope and thoroughness of the licensee's dose assessments for the five patients in question was adequate. The contract medical physicists referenced published examples of radiation injuries to estimate the doses delivered to the thighs of each patient. The dose estimates ranged from approximately 1,000 cGy for those patients who did not exhibit any observable side effects (Patients 1 and 2), to a maximum of 2,000 cGy for those patients who exhibited the most severe effects (Patients 3 and 5). The methodology employed by the physicists was reasonable considering the lack of other definitive information on which to base dose calculations.

6 NRC Independent Patient Dose Assessments (Charter Item No. 5)

6.1 Inspection Scope

The team conducted independent dose estimates for each patient, using assistance from an NRC medical expert consultant. The medical expert consultant also evaluated the probable deterministic effects resulting from the doses received to the skin of the thighs for the patients. The inspectors reviewed the medical expert consultant's dose assessment report and independently assessed the doses received to the skin of the thighs for patients who exhibited observable effects (Patients 3 through 5).

6.2 Observations and Findings

a. NRC Medical Expert Consultant's Assessment

The medical expert consultant determined that the intended treatment sites for Patients 1 through 5 likely received doses that were within 20 percent of the doses prescribed on the written directives. As described in Section 5, above, the licensee estimated that the maximum deviation from the prescribed dose for any of the five patients was approximately 16 percent.

The medical expert consultant determined that, since Patients 1 and 2 exhibited no observable effects and the threshold for erythema is approximately 300 cGy, those patients received less than 300 cGy to the skin of the thighs. However, as described in Section 5 above, the licensee estimated that the dose to the skin of the thighs of Patients 1 and 2 was 1,000 cGy based on its assumption that 1,000 cGy was the dose threshold for erythema. The medical expert consultant determined that Patients 3 and 5 received between 1,800 cGy and 2,200 cGy to the skin of the thighs, compared with the licensee's estimate of 2,000 cGy to those areas. The medical expert consultant determined that Patient 4 received between 1,500 cGy and 2,000 cGy to the skin of the left thigh. The licensee estimated that the patient received 1,500 cGy to that area.

The medical expert consultant determined that Patients 1 and 2 did not exhibit any observable effects as a result of radiation dose to the unintended treatment sites. For Patients 3, 4, and 5, the medical expert consultant determined that each patient exhibited moist desquamation and late effects due to skin breakdown as a result of the radiation dose that each received to the unintended treatment sites. In his dose assessment report, the medical expert consultant stated that Patient 3 had been referred to a plastic and reconstructive surgeon for wound care and removal of necrotic tissue, and that Patient 5 had been referred

to a Wound Center for treatment of the injuries. The medical expert consultant did not make the referrals.

b. NRC Inspectors' Assessment

The inspectors calculated the skin dose rates to Patients 3, 4, and 5 on the basis of the geometry of the applicator and the location of the sources with respect to the patients' skin. Because of the difficulty of accurately estimating the total exposure duration in each case, the NRC relied on the licensee's approach of estimating total dose based on the appearance of the skin lesions. Because Patients 1 and 2 did not develop skin lesions, the NRC assumed that any doses that may have been received by these patients must have been below the threshold dose (300 cGy) for appearance of such lesions.

Based on the above approach, NRC's calculations showed substantial agreement with the licensee's dose estimates for Patients 3 and 4. However, NRC's dose estimates indicated a dose rate for Patient 5 that is significantly higher than that estimated by the licensee. Specifically, the licensee calculated a dose rate of 150 cGy per hour and the NRC calculated a dose rate of 500 - 800 cGy per hour. This does not necessarily indicate disagreement on the total dose, which is based on the appearance of the lesions exhibited by the patient, but only a possible disagreement on exposure duration.

Given the observable effects exhibited by each patient, the team determined that the inner thighs of Patients 3, 4, and 5 received approximately 2,000 cGy, 1,500 cGy, and 2,000 cGy, respectively.

The team determined that the treatments of Patients 1 through 5 resulted in medical events, as defined in Title 10 Code of Federal Regulations (CFR) Section 35.3045(a)(3), because they all received a radiation dose to the skin of the upper thighs (i.e., unintended treatment sites) that was more than 100 cGy and more than 50 percent of the dose expected from the administration defined in the written directive. (Note: The dose expected to the skin if the treatments were administered in accordance with the written directive was about 50 cGy).

6.3 Conclusions

The team's independent dose assessments for Patients 3, 4, and 5, including the estimate provided by the medical expert consultant agreed substantially with the licensee's dose assessments for those patients. The team estimated dose rates based on the configuration of the brachytherapy sources with respect to the patients' skin, and the total dose based on the appearance of the skin lesions. The team determined that this was a reasonable approach, considering the lack of accurate estimates of exposure durations in each case. The team estimated the doses to Patients 1 and 2 on the assumption that the maximum doses received by these patients were below the threshold for the appearance of skin lesions induced by radiation exposure. This threshold was determined by the medical consultant to be about 300 cGy.

7 Brachytherapy Procedures (Charter Item No. 6)

7.1 Inspection Scope

The team reviewed selected licensee procedures for manual low-dose-rate brachytherapy, and evaluated their adequacy for routine and emergency conditions. The inspectors interviewed selected individuals including the authorized user, the director of the radiation oncology department, and the RSO. The inspectors observed a contract medical physicist demonstrate implementation of the licensee's procedures for administrations requiring a written directive for low-dose-rate brachytherapy. The inspectors reviewed written directives, simulation films, treatment plans for approximately 70 percent of the low-dose-rate brachytherapy treatments that the licensee administered between January 2003 and April 2005, the licensee's procedures for administrations requiring a written directive for low-dose-rate brachytherapy, and selected Radiation Safety Committee (RSC) meeting minutes.

7.2 Observations and Findings

Prior to each brachytherapy treatment administration, an authorized user prepared a written directive. For each case, the written directive included the patient's name, the radionuclide, treatment site, and dose. After implanting the applicator, but prior to implanting the radioactive sources, the licensee took simulation films with the dummy sources loaded in the applicator to verify the correct position of the applicator and the sources. Since the dummy sources were the same diameter as the 3M sources, which were larger than the Amersham sources, the licensee potentially missed an opportunity to identify that the Amersham sources would not be held in position by the applicator spring.

The licensee's procedures for administrations requiring a written directive did not provide high confidence that brachytherapy administrations were in accordance with the written directives. Specifically, the procedures did not include steps or cautions to verify that the sources used with the applicator were appropriate to administer the treatment as prescribed in the written directive. Therefore, the licensee did not recognize prior to the first use of the applicator that the Amersham sources were not appropriate for use in the applicator without the use of other compensatory measures to prevent their movement during treatment.

The licensee used simulation film data to enter three dimensional data into its treatment planning computer. The treatment planning computer was used to generate the treatment plan, and the treatment plan was reviewed and approved by the authorized user prior to treatment. After completion of the treatment plan, a second physicist or a dosimetrist independently verified that the data entry was accurate. In addition, the treatment plan calculations were verified by manually calculating the dose. Prior to implanting the sources, the licensee staff verified patient identity by more than one method. The inspectors did not identify that any additional examples of medical events occurred before January 2004 or after March 2004.

The licensee's procedures for administrations requiring a written directive referenced NRC regulatory requirements that were no longer in effect and that were deleted after the NRC revised the requirements in 10 CFR Part 35. The revised requirements became effective on April 24, 2002. Specifically, the licensee's procedures: (1) referenced terms that were no longer defined in 10 CFR Part 35 (e.g., "recordable event" and "misadministration"); (2) were silent regarding the reporting requirements for a medical event; and (3) referenced a written directive form that did not include the prescribed dose prior to administration for cesium-137 brachytherapy treatments.

The licensee's emergency procedures for brachytherapy included actions to be taken in the event that the patient moved or removed the applicator during treatment. The team informed the licensee's staff regarding the identified deficiencies in the licensee's brachytherapy procedures.

7.3 Conclusions

The licensee's procedures for manual, low-dose-rate brachytherapy administrations were inadequate. The licensee 's procedures did not require verification that the sources used with the applicator were appropriate to administer the treatment as prescribed on the written directive. In addition, the licensee's procedures referenced obsolete requirements that existed prior to the April 2002 revision of 10 CFR Part 35. The licensee's use of inadequate procedures was a contributing factor to the medical events.

8 Licensee Response and Corrective Actions (Charter Item No. 7)

8.1 Inspection Scope

The team evaluated the licensee's identification and response to patient erythema and/or ulcerations, including any corrective actions to the medical procedures. The inspectors interviewed the authorized user, selected contract medical physicists, and the RSO. The inspectors examined selected brachytherapy equipment. In addition, the inspectors reviewed selected records, including the licensee's written procedures for administrations requiring a written directive, the licensee's written directive form for cesium-137 brachytherapy treatments, RSC meeting minutes, memoranda from contract medical physicists, and the licensee's proposed Corrective Action Plan (CAP).

8.2 Observations and Findings

a. Licensee Response

Patients 1 and 2 did not exhibit any adverse observable effects, such as erythema or ulceration, from their brachytherapy treatments. Licensee staff continued to follow-up on Patients 3, 4, and 5 and they notified the patients and their referring physicians regarding the problems encountered as a result of the treatments. The authorized user examined Patients 3, 4, and 5 in May 2004. At that time, the authorized user informed Patients 3, 4, and 5 that the sores were the result of source movement during treatment. The authorized user examined Patients 3, 4, and 5 on additional occasions between June 2004 and January 2005.

In June and August 2004, the authorized user noted that the injuries on the thighs of Patient 3 were healing. In January 2005, the authorized user identified that Patient 3 had devascularization and scar tissue on the medial aspects of both upper thighs, each measuring about 1 centimeter in diameter. During follow-up of Patient 3 on February 15, 2005, the authorized user identified a 1.5 centimeter ulcer on the medial aspect of the upper left thigh and necrosis due to devascularization measuring 1 centimeter on the medial aspect of the upper right thigh. The authorized user reiterated to the patient that the sores were the result of source movement during treatment. In addition, the authorized user discussed the condition of Patient 3 with her referring physician.

In December 2004, the authorized user noted that Patient 4 had an ulcer on the medial aspect of the upper left thigh measuring about 4 centimeters by 3 centimeters.

Patient 5 was seen by the authorized user on April 26, 2004. The authorized user identified that the patient had two small ulcers on the medial aspect of the right upper thigh. The superior ulcer on the right thigh measured about 3 centimeters by 2.5 centimeters. The inferior ulcer on the right thigh measured about 2 centimeters by 1 centimeter. The authorized user also identified that the patient had an ulcer on the medial aspect of the left upper thigh that measured about 8 centimeters by 4 centimeters. In June and August 2004, the authorized user noted that the injuries on the thighs of Patient 5 were healing.

On March 31, 2005, the authorized user informed Patients 3, 4, and 5 that their thigh injuries from brachytherapy were reported to the NRC.

b. Immediate Corrective Action

In April 2004, immediately after the licensee identified that the Amersham sources could change position during brachytherapy treatments, the licensee initiated actions to prevent similar events. Based on a recommendation from Physicist C, the licensee treated subsequent patients with the applicator using a plastic tandem and pusher (reference Attachment D) rather than the spring to hold the tandem sources in position within the applicator. The solid, rigid plastic pusher ensured that the 3M and Amersham sources would remain in place within the applicator during treatments. The licensee promptly informed all applicable licensee staff about the use of the plastic tandem and pusher instead of the applicator spring.

c. Long-Term Corrective Action

On April 4, 2005, Physicist C initiated revisions to the licensee's written directive form for brachytherapy treatments and the licensee's procedures for ensuring that brachytherapy treatments were completed in accordance with written directives. Physicist C planned to revise the written directive form to include the prescribed dose prior to administration for cesium-137 brachytherapy treatments. Physicist C planned to revise the licensee's procedures for administrations requiring a written directive so that the procedures: (1) did not reference terms that were no longer defined in 10 CFR Part 35 (e.g., "recordable event" and "misadministration"); (2) no longer referenced treatments that were no longer conducted by the licensee; and (3) reflected the current reporting requirements in 10 CFR Part 35. Physicist C also considered revision of the licensee's procedures for administrations requiring a written directive so that they included acceptance testing of new brachytherapy applicators. In addition, Physicist C planned to ensure that all applicable licensee staff were trained on the revised written directive and the revised procedures for ensuring that brachytherapy treatments were in accordance with written directives prior to the next brachytherapy treatment.

The licensee began development of long-term corrective actions on April 4, 2005, ten days after the licensee identified the medical events associated with the

treatments of Patients 3 and 4. The licensee submitted its CAP to the NRC on April 12, 2005. The licensee used NRC Information Notice 96-28, "Suggested Guidance Relating to Development and Implementation of Corrective Action" to assist with development of its CAP. The CAP included: (1) the need for a Root Cause Analysis Team to conduct a complete and thorough assessment of all precursor and current processes affecting patient outcomes as a means of identifying the root cause of the medical events; (2) enhancement of the licensee's audit program; (3) the need for the RSC to review educational needs, and problem identification and resolution techniques; and (4) notification of the NRC whenever an event involving unusual circumstances and/or outcomes occurs.

8.3 Conclusions

The licensee's identification and response to patient erythema and/or ulcerations included periodic examinations of Patients 3, 4, and 5, to assess their condition and healing. The licensee implemented effective corrective actions to the medical procedures to prevent similar medical events. However, the licensee did not promptly develop long-term corrective action.

9 Generic Concerns (Charter Item No. 8)

9.1 Inspection Scope

The team reviewed the circumstances associated with the five brachytherapy treatments. The inspectors interviewed the authorized user, selected contract medical physicists, and a representative of the applicator manufacturer, Mick Radio-Nuclear Instruments, Inc. In addition, the inspectors examined selected brachytherapy equipment and reviewed the instructions that the licensee received with the applicator.

9.2 Observations and Findings

As discussed in Item 3.2.a., the team determined that the instructions provided with the applicator were not adequate. In addition, the team determined that the distal end of the applicator spring is designed with an inward bend to prevent source movement down the center of the spring; however, the spring supplied with the licensee's applicator did not have an inward bend. The deficiencies described regarding the applicator instructions is a generic concern, as is the absence of the applicator spring's inward bend. These issues were referred to the FDA for its review and evaluation.

9.3 Conclusions

The team identified two generic concerns. The instructions provided with the applicator were inadequate. In addition, the licensee's applicator spring did not have an inward bend to prevent source movement during brachytherapy treatments. Both of the generic concerns were referred to the FDA.

10 Applicator Modifications (Charter Item No. 9)

10.1 Inspection Scope

The team evaluated the appropriateness of any modifications to the treatment device made by the licensee, i.e., whether the modifications were authorized, consistent with

FDA protocol, etc. The inspectors interviewed the authorized user, selected contract medical physicists, and the RSO. The inspectors examined selected brachytherapy equipment. In addition, the inspectors reviewed selected records, including RSC meeting minutes.

10.2 Observations and Findings

As discussed in Item 8.2.b., the licensee's immediate corrective action was to use a plastic tandem and pusher rather than the spring to hold the tandem sources in position within the applicator. Since the plastic pusher is of solid construction, it would provide assurance that the sources remained in position during treatment. The team determined that the licensee's use of a plastic tandem and pusher rather than the spring to hold the tandem sources in position was a modification of the applicator. The licensee's modification of the applicator was not regulated by the FDA because the FDA does not regulate the end user of the device.

10.3 Conclusions

The licensee's modification of the applicator to include a solid plastic pusher rather than use of the retaining spring was appropriate. The modification was not regulated by the FDA.

11 Notifications and Reports

11.1 Inspection Scope

The team evaluated the licensee's notification and reporting to the NRC of its identification of medical events resulting from brachytherapy treatments. The inspectors interviewed the RSO, the authorized user, selected contract medical physicists, and the referring physicians for all five patients. In addition, the inspectors reviewed the licensee's written report of the medical events.

11.2 Observations and Findings

In May 2004, licensee personnel reviewed the reporting requirements in 10 CFR Section 35.3045, "Report and Notification of a Medical Event," to determine whether the brachytherapy treatments of Patients 1 through 5 resulted in medical events. Physicists A and C understood that 10 CFR Section 35.3045(a)(1) defined a medical event as an event that results in a dose that differs from the prescribed dose by more than 50 cGy to an organ or tissue and the total dose delivered differs from the prescribed dose by 20 percent or more. In addition, Physicists A and C interpreted that 10 CFR Section 35.3045(a)(3) defined a medical event as an event that results in a dose to the skin that exceeds 50 cGy; a dose to the skin that exceeds 50 percent or more of the prescribed dose to the treatment site; and a dose that results in unintended permanent functional damage to an organ or a physiological system, as determined by a physician.

Title 10 CFR Section 35.3045(a)(1) defined a medical event, in part, as an event that results in a dose that differs from the prescribed dose by more than 50 cGy to an organ or tissue and the total dose delivered differs from the prescribed dose by 20 percent or more. Title 10 CFR 35.3045(a)(3) also defined a medical event as an event that results in a dose to the skin, organ or tissue other than the treatment site that

exceeds by 50 cGy the expected dose to the skin, organ, or tissue and is 50 percent or more of the dose expected from the administration defined in the written directive.

Physicists A and C understood the requirements in 10 CFR Section 35.3045(a)(1), but they misunderstood the requirements in 10 CFR Section 35.3045(a)(3). The contract medical physicists misinterpreted 10 CFR Section 35.3045(a)(3) because they focused only on the dose to the treatment site rather than dose to tissues or organs other than the treatment site that were 50 percent or more of the dose expected from the administration, and they erroneously applied a portion of 10 CFR Section 35.3045(b) that referenced "unintended permanent functional damage to an organ or a physiological system, as determined by a physician" to the requirement in 10 CFR Section 35.3045(a)(3).

Licensee personnel determined that the brachytherapy treatments for Patients 1 through 5 did not meet the criteria for a medical event described in 10 CFR Section 35.3045(a)(1) because the doses administered to the treatment sites were within 20 percent of the prescribed doses, with the largest deviation from the prescribed dose being 16 percent (for Patient 5).

Since Patients 1 and 2 did not exhibit any adverse observable effects and the authorized user determined that Patients 3, 4, and 5 had skin lesions that were healing with no unintended permanent functional damage to an organ or a physiological system, the contract medical physicists did not identify the circumstances of the treatments as medical events. However, as described in Section 6 above, the brachytherapy treatments of Patients 1 through 5 were medical events pursuant to 10 CFR Section 35.3045(a)(3), because they all received a radiation dose to the skin of the upper thighs (i.e., unintended treatment sites) that: (1) was more than 50 cGy above the dose expected for those areas from the administration defined in the written directive; and (2) was greater than 50 percent of the dose expected. (Note: The dose expected to the skin if the treatments were administered in accordance with the written directive was about 50 cGy).

The licensee's RSC met on May 19, 2004. Physicist A and another licensee staff member discussed the brachytherapy treatments for Patients 3, 4, and 5, that resulted in a range of adverse observable effects from erythema to moist desquamation. The staff discussed the root cause of the events and informed the RSC that the patients and their referring physicians were notified about the events. The staff informed the RSC that, for each of the three patients, the deviation of the administered dose from the prescribed dose was less than 20 percent, and the deviations did not result in the patients receiving less radiation than necessary to treat their diseases. The RSC was also informed that, based on clinical follow-up, all of the skin lesions were resolved, and the events were not reportable.

Physicist C re-examined the reporting requirements as they applied to the treatments of Patients 1 through 5 after completion of a patient dose reassessment in February 2005. Physicist C determined that the treatments of Patients 3 and 4 were medical events because at that time there was unintended permanent functional damage to an organ or a physiological system, as determined by a physician (the authorized user). Physicist C erroneously determined that the treatment of Patient 5 was not a medical event because the dose to the skin was not 50 percent or more of the prescribed dose to the treatment site. The authorized user prescribed a dose of 6,500 cGy and the

licensee estimated the dose to the patient's thigh to be 2,000 cGy. Physicist C did not recognize that the threshold for a medical event involving an unintended treatment site was not contingent on the prescribed dose to the intended treatment site.

On March 25, 2005, Physicist C recommended that the licensee notify the NRC that the treatments of Patients 3 and 4 resulted in medical events. However, the RSO waited for the authorized user to generate a document describing the incident details as a means of helping him communicate the medical events to the NRC. On March 28, 2005, the RSO received the authorized user's written descriptions of the incidents, and the RSO reported the medical events involving Patients 3 and 4 to the NRC Operations Center, approximately 72 hours after the physicist determined that the incidents constituted medical events.

On April 1, 2005, the team identified that the treatment of Patient 5 resulted in a medical event. Based on the team's explanation of the definition of "medical event" in 10 CFR Section 35.3045(a)(3), the licensee notified the NRC Operations Center on April 1, 2005, that the treatment of Patient 5 was a medical event, less than 24 hours after identification of the medical event.

On April 5, 2005, the team noted that the licensee's dose assessment for Patients 1 and 2 indicated that the maximum dose to the skin on both patients' thighs would have been 1,000 cGy, meeting the definition of a medical event in 10 CFR Section 35.3045(a)(3). The inspectors again explained the definition of "medical event" to licensee staff and requested the licensee to verify the doses to the patients' thighs to determine if additional medical events occurred. The licensee staff determined that the dose to the skin on both patients' thighs was 1,000 cGy and the treatments resulted in medical events. Therefore, on April 5, 2005, the licensee notified the NRC Operations Center that the treatments of Patients 1 and 2 were medical events, less than 24 hours after identification of the medical events.

The licensee notified all five patients and their referring physicians of the medical events on April 6, 2005. In addition, the licensee submitted written reports of the medical events to the NRC by letters dated April 6, 2005, and the reports were received by the NRC within 15 days of the licensee's identification of the medical events. The licensee also submitted subsequent addendums to some of the reports that provided additional information or corrections. The written reports included a description of the events, why the events occurred, the effects on the patients, immediate and long-term corrective actions, and when the patients and referring physicians were notified.

11.3 Conclusions

The licensee relied on the contract medical physicists to interpret NRC regulations regarding identification and notification of medical events. The licensee accepted the contract medical physicists' misinterpretation of 10 CFR Section 35.3045. In addition, when the RSC members reviewed the events, they focused on the dose to the skin, organ or tissue other than the treatment site that exceeds by 50 percent or more of the prescribed dose to the treatment site rather than by 50 percent or more of the dose expected to the skin from the administration defined in the written directive. The licensee's misinterpretation of the requirements in 10 CFR Section 35.3045(a)(3)

resulted in the licensee's failure to promptly identify that five medical events occurred. Therefore, the NRC was not afforded an opportunity to promptly evaluate the events.

12 Program Oversight

12.1 Inspection Scope

The inspectors evaluated the licensee's oversight of the implementation of its brachytherapy program. The inspectors interviewed the authorized user, selected contract medical physicists, and the RSO. In addition, the inspectors reviewed selected records, including RSC meeting minutes and memoranda from contract medical physicists.

12.2 Observations and Findings

The RSO determined that, since he was not a medical physicist, his responsibility was limited, in part, to receiving contract medical physicists' reports about the brachytherapy radiation safety program. Problems or concerns associated with the brachytherapy radiation safety program were typically communicated from the contract medical physicists to the RSO and the RSC during periodic RSC meetings. The RSO did not independently assess the condition of the licensee's brachytherapy radiation safety program, or take other steps to validate the information provided by the contract medical physicists.

The RSO rarely visited the brachytherapy department, observed brachytherapy activities, interviewed the contract medical physicists, or reviewed records associated with the brachytherapy program as a means of assessing implementation of the brachytherapy radiation safety program. Although the RSO was previously involved with Intravascular Brachytherapy (IVB) quality control checks, the licensee terminated IVB activities in late 2004. Afterwards, the RSO's involvement with the brachytherapy radiation safety program was limited to reviewing records of brachytherapy staff occupational exposure monitoring results, and conducting inventories and leak tests of brachytherapy sources.

The licensee relied on the contract medical physicists to audit the brachytherapy radiation safety program. Contract medical physicists conducted quarterly audits of the implementation of the licensee's procedures to ensure that brachytherapy treatments were conducted in accordance with written directives. The audits included 100 percent of the cases completed during the audit period. The contract medical physicists' audits included, among other things, treatment plan verification, patient identification verification, written directive completion, and nurse training completion. During periodic RSC meetings, the contract medical physicists briefed the RSC on the audit findings and any problems or concerns associated with brachytherapy activities. The licensee did not conduct any audits of the brachytherapy radiation safety program independent of the contract medical physicists.

12.3 Conclusions

The RSO's poor oversight of the brachytherapy radiation safety program significantly reduced his ability to: (1) ensure that radiation safety activities were performed in accordance with regulatory requirements; (2) identify radiation safety problems; (3) initiate, recommend, or provide corrective action; and (4) stop unsafe operations. The

licensee relied on the contract medical physicists to monitor activities relative to the licensee's brachytherapy radiation safety program; however, the contract medical physicists were also delegated the responsibility for the day-to-day implementation of the brachytherapy radiation safety program. As a result, the licensee missed opportunities to identify precursors associated with five medical events (e.g., limitations on the sources that should be used with the applicator, Physicist A's unfamiliarity with the two types of sources possessed by the licensee) and to promptly identify and report those medical events.

13 Exit Meeting

The team conducted a public exit meeting at the licensee's facility on April 21, 2005, to discuss the preliminary findings of the augmented inspection. The inspectors discussed how the special inspection, that was conducted in response to the first two reported medical events, was upgraded to an augmented inspection. The inspectors also presented the root cause and contributing factors associated with the medical events, concerns associated with the applicator, licensee corrective actions, and other preliminary inspection findings. The licensee summarized corrective actions that it had taken in response to the preliminary inspection findings. The licensee did not identify any information reviewed during the inspection and selected for inclusion in the inspection report as proprietary in nature.

14 Partial List of Personnel Contacted

St. Joseph Regional Medical Center

* Linda Aldridge, Registered Nurse
* Sharon Forgues, R.N., Risk Management Coordinator
* Jon D. Frazier, M.D., Radiation Oncologist
* John S. Greaney, Senior Director, Marketing
* Kathy Hawley, Director of Oncology
Nancy Hellyer, Chief Executive Officer, Trinity Health Systems
* Christopher Karam, Senior Director, Clinical Services
* Teresa Langley, Director, Radiation Oncology
* Carol Norris, R.N., Executive Director, Oncology
* Gary L. Perecko, President, South Bend Campus
* John D. Scheu, Ph.D., Radiation Safety Officer
Mike Stack, Public Relations Coordinator, Marketing
* Debra Wheeler, Risk Manager/Patient Safety Officer

Michiana Hematology and Oncology

Michael Method, M.D., Oncologist (Referring Physician)
Michael Rodriguez, M.D., Oncologist (Referring Physician)

Marshall County Ob/Gyn

Elizabeth Rutherford, M.D., Oncologist (Referring Physician)

Arete Medical Physics

Nathan Davis, M.S., Medical Physicist
Christopher Gouin, M.S., Medical Physicist
* Brent Murphy, M.S., Senior Medical Physicist

Mick Radio-Nuclear Instruments, Inc.

Ken Zabrouski, Vice President, Chief Engineer

Nuclear Regulatory Commission

* Robert G. Gattone, Jr., Senior Health Physicist, Materials Inspection Branch, Region III
Ronald E. Goans, Ph.D., M.D., M.P.H., Medical Expert Consultant
* John R. Madera, Chief, Materials Inspection Branch, Region III (AIT Leader)
* Viktoria Mitlyng, Public Affairs Officer
* Deborah A. Piskura, Health Physicist, Materials Inspection Branch, Region III
* Gary L. Shear, Deputy Director, Division of Nuclear Materials Safety, Region III
Sami Sherbini, Ph.D., Senior Advisor for Health Physics, Office of Nuclear Materials Safety and Safeguards

* Denotes the individuals who participated in the onsite public exit meeting on April 21, 2005.

15 List of Acronyms Used

AIT	Augmented Inspection Team
CAP	Corrective Action Plan
CFR	Code of Federal Regulations
cGy	Centigray
FDA	Food and Drug Administration
IVB	Intravascular Brachytherapy
NRC	Nuclear Regulatory Commission
RSC	Radiation Safety Committee
RSO	Radiation Safety Officer

16 Procedures Used

Management Directive 8.3, “NRC Incident Investigation Program”
Management Directive 8.10, “NRC Medical Event Assessment Program”
Regional Procedure RP-8.3, “Augmented Inspection Team Reports”
Inspection Procedure 93800, “Augmented Inspection Team”
Inspection Procedure 87132, “Brachytherapy Programs”

17 Partial List of Documents Reviewed

British Journal of Radiology article titled, “Single Dose Irradiation Response of Pig Skin: A Comparison of Brachytherapy Using Single, High Dose Rate Iridium-192 Stepping Source With 200 keV X-Rays” (July 2000)

“Textbook of Radiotherapy” by Gilbert H. Fletcher

Letter from Jon Frazier, M.D. to John Scheu, Ph.D. dated March 28, 2005

Licensee’s applicator instructions

RSC Meeting Minutes dated May 19, 2004

“Memorandum for Record” from Brent D. Murphy, MS, DABR dated March 25, 2005

The licensee’s “Quality Management Program for Brachytherapy” dated June 2004

Memo dated April 13, 2004, from Nate C. Davis, MS to the licensee regarding corrective action using the applicator

Written directives, treatment plans, and memoranda associated with the five treatments that resulted in medical events

Licensee’s corrective action plan dated April 12, 2005

Sealed Source and Device Registration IL-136-S-255-S (AEA Technology (Amersham) brachytherapy source model CDC.T1)

Sealed Source and Device Registration NR-460-S-906-S (Minnesota Mining and Manufacturing (3M) tube source model Series 6500, formerly 6D6C-CA)