The Truebeam System Varian Medical Systems International

Stereotactic Radiosurgery and Stereotactic Body Radiation TherapyStereotactic Body Radiation TherapyExploring RayStation Treatment Planning SystemStandard & Poor''s 500 Guide, 2011 EditionStandard and Poor's 500 Guide, 2012 EditionStandard & Poor's Stock ReportsRadiation-Oncology TherapyPerformance of Computer-designed Small-size Multistage Depressed Collectors for a High-perveance Traveling Wave TubeIndiaBritish Journal of Non-destructive TestingEPAC96Dosimetric Evaluation and Verification of Respiratory Motion Management System in Radiation OncologyDosimetric Verification of Respiratory-gated Radiation Therapy Using a Dynamic Phantom for Commissioning the Varian Real-time Position Management SystemA Comparative Analysis for Verification of IMRT and VMAT Treatment Plans Using a 2-D and 3-D Diode ArrayThe Limit of Resolution and Detectability of the ArcCHECK QA Phantom in Small Field Volumetric Modulated Arc Therapy and Stereotactic Radiosurgery Quality AssuranceComparison of Different Imaging Strategies in IGRT for the Thoracic Region Regarding Dose, Workflow and Image QualityIterative CBCT - Improving CBCT Image Quality at ProBeamUse of ClearView Gel Dosimeter for Quality Assurance and Testing of Stereotactic RadiosurgeryDosimetric and Biologic Characteristics of the Flattened and the Flattening-filter-free Beams of the TrueBeam SystemEvaluation of Dose Calculations and Couch Positional Accuracy in the Context of Dynamic Couch Trajectories Stanley H. Benedict Simon S. Lo Jui Wan Standard & Poor's Standard & Poor's Sushil Beriwal Peter Ramins S. Myers Chenguang Liu Nichole L. Hill Michael Joseph Dance Tara M. Gray Viktória Fekete Philippe Messmer Erik Joseph-Leonard Courter Joel Mullins

Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy Stereotactic Body Radiation Therapy Exploring RayStation Treatment Planning System Standard & Poor''s 500 Guide, 2011 Edition Standard and Poor's 500 Guide, 2012 Edition Standard & Poor's Stock Reports Radiation-Oncology Therapy Performance of Computer-designed Small-size Multistage Depressed Collectors for a High-perveance Traveling Wave Tube India British Journal of Non-destructive Testing EPAC96 Dosimetric Evaluation and Verification of Respiratory Motion Management System in Radiation Oncology Dosimetric Verification of Respiratory-gated Radiation Therapy Using a Dynamic Phantom for Commissioning the Varian Real-time Position Management System A Comparative Analysis for Verification of IMRT and VMAT Treatment Plans Using a 2-D and 3-D Diode Array The Limit of Resolution and Detectability of the ArcCHECK QA Phantom in Small Field Volumetric Modulated Arc Therapy and Stereotactic Radiosurgery Quality Assurance Comparison of Different Imaging Strategies in IGRT for the Thoracic Region Regarding Dose, Workflow and Image Quality Iterative CBCT - Improving CBCT Image Quality at ProBeam Use of ClearView Gel Dosimeter for Quality Assurance and Testing of Stereotactic Radiosurgery Dosimetric and Biologic Characteristics of the Flattened and the Flattening-filter-free Beams of the TrueBeam System Evaluation of Dose Calculations and Couch Positional Accuracy in the Context of Dynamic Couch Trajectories *Stanley H. Benedict Simon S.*

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written by internationally known experts in the field stereotactic radiosurgery and stereotactic body radiation therapy examines one of the fastest developing subspecialties within radiation oncology these procedures deliver large doses of radiation in one to five sessions to a precisely determined target often these techniques have proven to be

stereotactic body radiation therapy sbrt has emerged as an important innovative treatment for various primary and metastatic cancers this book provides a comprehensive and up to date account of the physical technological biological and clinical aspects of sbrt it will serve as a detailed resource for this rapidly developing treatment modality the organ sites covered include lung liver spine pancreas prostate adrenal head and neck and female reproductive tract retrospective studies and prospective clinical trials on sbrt for various organ sites from around the world are examined and toxicities and normal tissue constraints are discussed this book features unique insights from world renowned experts in sbrt from north america asia and europe it will be necessary reading for radiation oncologists radiation oncology residents and fellows medical physicists medical physics residents medical oncologists surgical oncologists and cancer scientists

raystation a new treatment planning system tps was purchased and recently commissioned for clinical use by the institution as part of the commissioning process an accurate model of the truebeam linear accelerator was made prior to clinical acceptances data collection importing measurements beam modeling point dose verifications and clinical plan comparisons are procedures that must be done in order to complete the commissioning of photon and electron energies during the beam modeling process various parameters were modified to achieve close matches between the computed and measured pdd curves as well as measured and computed beam profiles the tolerance objectives were to have computed data deviating from the measured data within the 2 in fall off regions 3 tolerance within in field and out of field regions and 10 tolerance in build up regions and penumbra regions 1 the dosimetric validation procedure followed point dose measurements were completed using both the arccheck phantom and the water tank the majority of the results met the set criteria except for some measurements blocked by mlc leaves or jaws when taken adjacent to the edge of fields to further confirm the goodness of modeled beams clinical treatment plans developed with the previously clinically commissioned pinnacle tps and imported into the raystation tps to generate new plans with same beam arrangements and control points and used as comparisons after clinical commissioning was completed for raystation software a feasibility of using fff beams to deliver identical or superior beam profile provided by conventional flattened beams of the same energy was investigated the objective of this research was to show that through sliding window treatment planning one can create optimized plans and hence no longer the technology of flattening filter is required in modern linear accelerators to explore this topic a two stage analysis was carried out first delivering doses in a water cube with 10 10 to 30 30 cm2

open field 6 mv flattened beams and also create 0 1cm thick square plane structures to be used when undergo the optimization process with 6 fff beams then scaling doses to prescribe 100 cgy at the center of the plane for comparison purpose the overall uniformity of line profile for fff beams across the cax at 10 cm depth showed 1 to 2 superior to flattened beams for the clinical treatment plans comparison ten patients were selected with five head and neck cancer plans as well as five lung and mediastinum cancer plans original plans were all completed with 6 mv flattened beams and approved by radiation oncologists new plans were accomplished with 6 fff beams and same coverages of ptvs were achieved most of average mean doses to critical structures and normal tissue volumes receiving 5 10 20 and 30 of the prescription dose were reduced with fff plans with slightly increased average max doses

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the most succinct user friendly radiation oncology therapy guide delivers up to date regimens in clear and easy to understand ways the unique tabular design of radiation oncology therapy enables you to instantly locate and implement the proper radiation treatment regimen supported by the latest practice guidelines peer reviewed literature and expert insights this trusted guide integrates critical information for both office and hospital based practices every chapter includes relevant information for each cancer epidemiologic data per stage and survival data the role of radiation oncology for each cancer stage color images of radiation planning per stage and tabular form specific information for each regimen and each regimen includes patient population studied and journal reference dose and duration planning techniques efficacy and outcomes toxicities and dose modification and supportive care

respiratory caused intra fraction motion is an important factor that can affect radiation treatment accuracy although the major effect of respiratory motion is in lung tumors other tumor sites in thoracic and abdomen such as esophagus and liver cancer can also move significantly depending on patient s geometry this thesis explains dosimetric discrepancy caused by respiratory motion during radiotherapy describes different types of respiratory management system and specifically discusses the clinical implementation of respiratory gating system including varian rpm system commissioning machine quality assurance patient specific quality assurance and dosimetric evaluation of gating intensity modulated radiation therapy imrt treatment in order to verify gated treatment plan dynamic quality assurance phantoms have been developed to simulate patient s specific respiratory motion modifying traditional quality assurance devices a quasar respiratory motion phantom has been used to commission the varian rpm system on ct simulator edge linear accelerator and truebeam linear accelerator

currently surgery chemotherapy and radiation therapy are the main modalities used to treat cancer when implementing radiation therapy into the course of treatment a common goal is applied to all types of cancer deliver the prescribed dose to the target while sparing as much normal tissue as possible delineation of the gtv gross tumor volume is contoured onto the treatment planning ct and a margin is applied expanding the volume in order to create the ptv planned target volume while this expansion does help to deliver the prescribed dose to the target it simultaneously hinders the ability to spare normal tissue furthermore tumors in the thoracic and abdominal cavities are subject to respiratory motion which can cause the undesired effect of moving the target out of the radiation field a possible result from this type of motion is under dosing the target and over dosing the surrounding normal tissue respiratory gated radiotherapy rgrt has been developed to help manage the intrafractional motion caused by respiration during treatment respiratory gating allows the radiation beam to be turned on and off when the tumor moves into and out of a planned position the goal of this project is to construct a motorized phantom capable of reproducing the motion a tumor undergoes during respiration in order to commission the varian rpm real time position management system package on a truebeam linear accelerator measurements will be made to verify that the planned dose agrees with the delivered dose using both an ion chamber to measure the dose delivered to a point within the moving target and the mapcheck2 to measure the dose distribution multiple breathing rates are available to be used however one breathing rate was chosen for data collection in this work detailed discussion on motorized phantom design and analysis of the acquired data will

be presented

with the added complexity of current radiation treatment dose delivery modalities such as imrt intensity modulated radiation therapy and vmat volumetric modulated arc therapy quality assurance qa of these plans become multifaceted and labor intensive to simplify the patient specific quality assurance process 2d or 3d diode arrays are used to measure the radiation fluence for imrt and vmat treatments which can then be quickly and easily compared against the planned dose distribution because the arrays that can be used for imrt and vmat patient specific quality assurance are of different geometry planar vs cylindrical the same imrt or vmat treatment plan measured by two different arrays could lead to different measured radiation fluences regardless of the output and performance of linear accelerator thus the purpose of this study is to compare patient specific qa results as measured by the mapcheck 2 and arccheck diode arrays for the same imrt and vmat treatment plans to see if one diode array consistently provides a closer comparison to reference data six prostate and three thoracic spine imrt treatment plans as well as three prostate and three thoracic spine vmat treatment plans were produced radiotherapy plans for this study were generated using the pinnacle tps v9 6 philips radiation oncology systems fitchburg wi using 6 mv 6 mv fff and 10 mv x ray beams from a varian truebeam linear accelerator varian medical systems palo alto ca with a 120 millenium multi leaf collimator mlc each imrt and vmat therapy plan was measured on sun nuclear s mapcheck 2 and arccheck diode arrays imrt measured data was compared with planned dose distribution using sun nuclear s 3dvh quality assurance software program using gamma analysis and dose volume histograms for target volumes and critical structures comparison vmat arc plans measured on the mapcheck 2 and arccheck were compared using beam by beam analysis with the gamma evaluation method with sun nuclear s snc patient analysis software mapcheck 2 showed a slightly better agreement with planned data for imrt verifications with a mean pass rate of 99 4 for clinically used acceptance criteria of 3 3mm mapcheck 2 s 99 4 mean pass rate for imrt verifications was 1 4 higher than arccheck s mean pass rate for vmat verifications the mapcheck 2 had a mean pass rate of 99 6 and 100 for each arc respectively resulting in a 1 25 to 1 92 higher mean passing rates than those measured by the arccheck using an acceptance criteria of 3 3mm mapcheck 2 showed consistently higher roi specific mean gamma passing rates ranging from 0 2 to 5 6 while neither diode array showed any advantage in regards to d95 measurements within the ptv mapcheck 2 again showed closer comparison data in the ctv gtv with an absolute deviation of 1 14 gy compared to 3 39 gy as measured by the arccheck lastly while the mapcheck 2 and arccheck both closely matched with the reference doses within the ptv and ctv gtv the arccheck consistently overestimated the maximum absolute dose to all roi from 0 026 gy to 2 243 gy in conclusion the mapcheck 2 diode array measured data more closely matched with planned data compared to the arccheck diode array for imrt verifications while mapcheck 2 showed a marginally better gamma passing rates over the arccheck diode array the arccheck s ability to simultaneously measure flatness symmetry output and mlc positional accuracy as a function of gantry angle make it a more realistic and efficient measurement device for vmat verifications

purpose to determine the limit of detectability and resolution of the arccheck qa phantom sun nuclear inc for quality assurance of volumetric modulated arc therapy and stereotactic radiosurgery procedures when used in small field sizes methods eight different square field sizes 0 6x0 6 1x1 2x2 3x3 5x5 7x7 10x10

15x15 cm2 were measured on the arccheck qa phantom at three different gantry angles 0 90 and 270 degrees using a 6 mv beam at its maximum dose rate of 600 mu min and a dose computed from a 200 mu beam from the varian edge linear accelerator varian medical systems palo alto ca at the university of toledo dana cancer center four different types of errors were introduced into quality assurance analysis procedures measured square field sizes were compared against the same measured square field sizes with induced collimator and mlc errors induced collimator errors were defined by an expansion of the jaw defined field size by 1 mm on all axes a collimator shift of 1 mm on the x2 and y2 axes a table shift by 1 mm vertically and longitudinally at 270 and 90 degrees and a table shift of 1mm laterally and longitudinally for angles of 0 and 180 degrees mlc induced errors included the addition of one and subsequently two opposing mlc leaves in the center of each square field dose distributions for the normal square fields and square fields with induced errors were imported into snc patient software sun nuclear corporation melbourne fl in the form of dicom rt dose files and measured dose distributions were compared between the normally measured square fields and fields containing induced errors percent pass rates were computed using gamma analysis criteria of 2 mm 2 with a threshold value of 20 point dose ratios were also analyzed for fields with induced mlc errors and output factors were calculated in order to determine the magnitude of the effect that these induced errors had on output measurements as compared with the ability of gamma criteria analysis in snc to catch errors a point dose calibration pertaining to each field size at each photon energy of the truebeam and edge linear accelerators varian medical systems palo alto ca was calculated by measuring a point dose at a range of field sizes at each energy 6 mv 6 fff and 10fff for the edge and 6 mv 6fff 10 mv and 18 mv for the truebeam and dividing this number by the treatment planning system calculated point dose calculated in pinnacle to obtain a cgy mu dose calibration an extradin a16 micropoint chamber extradin a1sl standard imaging inc middleton wi was placed in the center of the plug insert in the center of the arccheck phantom and a cnmc 206 electrometer cnmc instruments nashville tn reading pertaining to a beam of 200 mu at different field sizes for each energy the dose calibration factor for each energy was calculated and applied to six different patient specific point dose qa analyses in order to determine the field size dependence of the dose calibration and to determine if the calibration improved the overall qa pass rate as well as the pass rate for individual fields for srs qa finally mlc errors were induced into three different patient specific qa procedures performed on the edge and truebeam linear accelerators two opposing mlc leaves were extended into the middle of the field leaf position 30 at each control point of the first 180 180 degree clockwise field in each of the two patient qas on the edge and truebeam linear accelerators the effect of extending the mlc leaves was analyzed using gamma analysis in snc patient software a point dose analysis of each qa was also taken into account and compared with the result measured using gamma criteria results examination of results in snc patient software between measured normal fields and those with induced jaw field size errors indicate that the gamma criteria percent pass rates decrease significantly when errors are induced in the quality assurance analysis pass rates for a table shift and increase in field sizes by 1 mm on all axes of the square field indicate the greatest average errors for all gantry angles measured evidence of normal error detection was seen at a field size of 3x3 cm2 for a table shift at a 0 degree gantry angle the field size at which normal error detection was seen by the arccheck was indicated at 2x2 cm2 for the 1mm margin errors induced at 90 degree and 270 degree gantry angles the field size at which normal error detection was seen by the arccheck with mlc error induction into square field sizes was indicated at a field size of 2x2 cm2 two qa procedures that did not improve by applying the field size specific calibration factor

decreased by an average of 0 44 three patient specific quality assurance procedure dose distributions measured with an induced mlc error indicate that errors in mlc leaf position when applied to all control points of a full 360 degree arc are indicated with a lower percent gamma dta criteria pass rate these pass rates were 77 4 and 96 1 on the edge and 96 5 on the truebeam accelerator respectively when a measured normal dose distribution and a dose distribution with an induced mlc error were compared in snc patient software of the six patient specific quality assurance procedures for which a field size specific point dose calibration factor was applied four were improved significantly by an average of 87 6 with the application of a field size specific calibration factor discussion and conclusion this work indicates the potential for having the ability to detect potential errors in vmat quality assurance for small field sizes using the arccheck qa phantom the ability of the arccheck to detect uncertainties in quality assurance procedures is based on the size of the field and the position and spacing of the diode detectors gamma analysis and point dose measurements indicate a 3x3 cm2 field size as the smallest field size at which accurate quality assurance is analyzed pass rates resulting in an induction of mlc errors in square field sizes can be utilized to predict pass rates resulting from the induction of mlc errors in patient specific quality assurance procedures it is suggested that a field size specific cgy mu calibration factor is utilized in order to more accurately predict patient specific point dose measurements

image guided radiation therapy igrt is one of the most sophisticated application of modern radiation oncology during an igrt procedure an online image is taken of the patient lying on the treatment couch after registration of the online and topometric images the patient is moved with the couch to the treatment position using igrt it is possible to increase the precision and accuracy of radiotherapy and therefore to reduce safety margins during treatment planning different imaging procedures are available on varian truebeam machine these are planar images with kilovoltage kv or megavoltage mv energies and kilovoltage cone beam computed tomography kv cbct in the case of mv planar imaging we measured 6 mv energy with 1 5 and 3 monitor units in the case of planar kv imaging we used with 3 different kv values and 4 different mas values in case of kv cbct we used the same 3 kv parameters as for planar kv images but we set only 270 mas there are many opportunities to measure the dose which come from igrt in our study we used thermoluminescent dosimeters tlds the rti barracuda system and ctdi phantom the image quality is also an important factor which was evaluated by the iba primus l phantom and catphan 504 phantom we measured the necessary time for all the three modalities we collected the dose results the line pair resolution the low and high contrast resolution and the summary of points which originate from the human observers ratings the lowest dose was measured in the planar kv imaging the following is the kv cbct the highest dose can be attributed to the mv imaging 140 kv with 10 mas had the worst low and high contrast resolution because the saturation of the detector in some case the low and the high contrast test items are getting undetectable because too much photon are incident to the detector in planar mv imaging and kv cbct imaging the machine s default setting is acceptable to be used in the daily routine in kv images it is possible to reduce mas because it reduces the dose of the phantom surface while the image quality remains acceptable image guided radiation therapy igrt is one of the most sophisticated application of modern radiation oncology during an igrt procedure an online image is taken of the patient lying on the treatment couch after registration of the online and topometric images the patient is moved with the couch to the treatment position using igrt it is possible to increase the precision and accuracy of

radiotherapy and therefore to reduce safety margins during treatment planning different imaging procedures are available on varian truebeam machine these are planar images with kilovoltage kv or megavoltage mv energies and kilovoltage cone beam computed tomography kv cbct in the case of mv planar imaging we measured 6 mv energy with 1 5 and 3 monitor units in the case of planar kv imaging we used with 3 different kv values and 4 different mas values in case of kv cbct we used the same 3 kv parameters as for planar kv images but we set only 270 mas there are many opportunities to measure the dose which come from igrt in our study we used thermoluminescent dosimeters tlds the rti barracuda system and ctdi phantom the image quality is also an important factor which was evaluated by the iba primus l phantom and catphan 504 phantom we measured the necessary time for all the three modalities we collected the dose results the line pair resolution the low and high contrast resolution and the summary of points which originate from the human observers ratings the lowest dose was measured in the planar kv imaging the following is the kv cbct the highest dose can be attributed to the mv imaging 140 kv with 10 mas had the worst low and high contrast resolution because the saturation of the detector in some case the low and the high contrast test items are getting undetectable because too much photon are incident to the detector in planar mv imaging and kv cbct imaging the machine s default setting is acceptable to be used in the daily routine in kv images it is possible to reduce mas because it reduces the dose of the phantom surface while the image quality remains acceptable

the probeam proton therapy system offers cbct imaging for patient setup with a feldkamp davis kress fdk algorithm with a kernel based scatter correction for the truebeam radiotherapy system varian medical systems commercially offers for head and pelvis protocols additionally an advanced reconstruction technique u2013 iterative cbct icbct using a statistical reconstruction and in the case of pelvis protocol a deterministic boltzmann transport equation solver based scatter correction preliminary results from an early evaluation of probeam clinical head neck and pelvis scans reconstructed with icbct show a significant improvement of image quality icbct reconstructions show a reduction of cone beam streak and shading artifacts and noise resulting in enhancements of soft tissue definition icbct will be implemented at probeam and probeam 360u00b0 to improve visualization and facilitate more precise patient setup the improved image quality is expected to enable new applications like usage of cbct images for replanning and adaptive radiotherapy at probeam and probeam 360u00b0

there exists a lack of accurate reproducible three dimensional dosimetry techniques for stereotactic radiosurgery srs commissioning and quality assurance this experiment evaluates the use of clearview gel dosimeters as an alternative to current methods for small field dosimetry in srs testing clearview differs from other gel dosimeters in that it uses tetrazolium salt in its chemical make up in place of traditional fricke type compounds using a varian truebeam radiotherapy system to deliver the radiation three vials of clearview gel dosimeter were tested in three different dose delivery scenarios the first test examined the dosimeter s response to a static beam with the dose isocenter targeted to the centroid of the vial the second evaluation consisted of a full rotational srs delivery about the center of the dosimeter lastly a complete end to end treatment plan was performed to evaluate the accuracy of the dosimeter in a full srs

procedure the three dosimeters were then scanned to measure the dose distribution throughout the gel finally the resulting data was compared to the initial treatment plan to determine the accuracy of the gel according to the comparisons performed the clearview gel showed capability of sub millimeter spatial accuracy across the three evaluations with a maximum geometric uncertainty of 1 2 mm based on these results clearview gel shows promise for possible use in srs dosimetry applications in clinical settings

in recent years the potential application of the flattening filter free fff photon beam in modern linac systems have been a topic of significant interest compared to flattened beams fff beams have some apparent advantages including reduced treatment time lower scatter to organs at risk oars and decreased neutron contamination the primary objective of the research in this thesis has been to investigate the dosimetric and biologic characteristics of the flattened beam and the fff beam of the truebeam tb system using monte carlo mc simulations we have also investigated the possibility of further reducing the dose to oars from the treatments delivered with 6 mv fff beams this project includes two different parts in the first part we evaluated the differences in treatment plans between the flattened beam and the fff beam in the second part based on the virtualinac system a mc model was built to simulate the tb system based on our findings we propose the concept of the specter soft spectrum filter to further reduce the dose to oars from 6 mv fff beam using the static imrt techniques clinical cases were used to investigate the impact of the specter on the dose distributions in the future direction of the project field size specific design of the specter will be described

the varian truebeam stx linear accelerator features a developer s mode in which treatment plans can be programmed that include patient couch motion during radiation delivery the combination of synchronous couch gantry trajectories with varian volumetric modulated arc therapy vmat optimizations called rapidarc can result in a treatment technique that has been designated virtual isocenter rapidarc vira prior to its implementation the accuracy of dose calculations in the varian eclipse treatment planning system on which the rapidarc optimization depends must be validated as well as the positional accuracy of the truebeam patient couch the dose calculation accuracy was evaluated extrinsically through the delivery of clinical dynamic multileaf collimator dmlc intensity modulated radiotherapy imrt treatment plans as a function of source to surface distance ssd and measurement with ionization chamber and gafchromic ebt3 film parameters intrinsic to dose calculations in eclipse the dosimetric leaf gap dlg and leaf transmission lt were also investigated for their dependence on ssd the positional accuracy of the treatment couch was assessed through the generation of treatment plans with static couch gantry static couch rotating gantry and synchronous couch and gantry motion with measurement of the real time ionization chamber current positioned in a cylindrical phantom during radiation delivery the relative agreement of ionization chamber measurements to eclipse dose calculations for dmlc imrt treatment plans decreased by 1 5 0 3 over ssds in the range of 85 cm to 135 cm less than 1 0 deviation from standard clinical reference conditions of 100 cm ssd gafchromic ebt3 film measurements were consistent with ionization chamber results though noise in the film data at low doses resulted in large uncertainties measurements of dlg were independent of ssd following corrections for geometric projection lt showed a dependence on ssd of 0 09 0 02 over the ssd range investigated the ionization chamber current

measurements for synchronous couch and gantry rotation analogous to the proposed vira technique indicated a maximum deviation of 0 2 cm relative to treatment isocenter equal to the deviation observed for the rotating gantry static couch treatment analogous to conventional vmat delivery these results indicate that the varian truebeam and eclipse maintain the necessary positional and dosimetric accuracy required for vmat treatments involving dynamic couch trajectories

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